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Biosystematic studies on the Simuliidae (Diptera) of the Amazonia onchocerciasis focus

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CONTENTS

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Synopsis. A comprehensive revision of the systematics, distribution, biology and medical importance of the fourteen simuliid species in the Amazonia onchocerciasis focus is presented with special emphasis on Brazil. The systematics section provides keys to the adults, pupae and larvae, full morphological descriptions, taxonomic discussions and distribution in Latin America; six new synonyms and three lectotypes are created. The relative importance of these species in both the Brazilian and Venezuelan parts of the focus as well as in other parts of Latin America is then discussed by reviewing their distribution in the focus, the biology of each species and the medical importance of the vector species. The paper provides a baseline for new biomedical studies being initiated in Brazil on vector simuliids.

INTRODUCTION

Human onchocerciasis is a rural disease caused by a filarial nematode worm (*Onchocerca volvulus*) whose skin-inhabiting larvae (microfilariae) produce loss of elasticity, de-pigmentation and itching of the skin, loss of visual acuity, and in severe cases blindness. It affects about 17 million people, mainly in Africa, but also in Latin America. Before 1965 onchocerciasis in Latin America was only known in Mexico, Guatemala and northern Venezuela, but during that decade new foci were discovered in Colombia, Ecuador, Brazil and southern Venezuela as development of rural areas accelerated (Shelley, 1988a). The disease was first recorded in Brazil in 1967 from a North American missionary child who had been living at a mission post in the Yanomami area in northern Brazil (Map 1), and later Moraes (Moraes *et al.*, 1979) showed the presence of a discrete focus of this disease principally involving Yanomami Indians in Amazonia. The disease was then detected in the adjacent region of Venezuela (Rassi *et al.*, 1977). The exact prevalence of onchocerciasis could not be calculated at the time because the inaccessibility of the area precluded the examination of representative numbers of Indians. The epidemiological and some entomological work carried out during the 1970s in this area of Brazil, its relevance to other foci in Latin America and views on the future dispersal and control of human onchocerciasis have now been reviewed (Moraes, 1991; Moraes & Shelley, 1986; Moraes *et al.*,1979; Shelley, 1988a, 1991).

The major objectives of entomological work in the Brazilian part of the focus were to investigate the simuliids present in this hitherto unprospected region and to determine the vector species of *O. volvulus*. Later, studies on vector species were made in areas circumjacent to the focus in order to assess the feasibility of onchocerciasis dispersing to these areas through infected individuals passing from the focus along the Northern Perimeter road to farming areas around Boa Vista. When this possibility was shown to be minimal because of disrepair of the road and poor vector susceptibility to *Onchocerca volvulus* (Shelley *et al.*, 1987b) interest in onchocerciasis and its vectors waned. However, the finding of an autochthonous case of the disease at Minaçu, Goias, 2500 kms to the south of the Amazonia focus prompted recommendations for further research into the disease in Brazil (Moraes, 1991; Shelley, 1991) and epidemiological and entomological research have now recommenced in the Amazonia focus with a view to assessing control strategies for the disease. Access to the Amazonia focus is now easier because of increased military manoeuvres and the creation of the Yanomami Sanitary District by the Ministry of Health. During the 1970s the presence, at the Serra dos Surucucus, of tin miners (many from Minaçu) is thought to be responsible for the dissemination of onchocerciasis to the new Goias focus. An invasion during the last decade of up to 40,000 tin and gold miners and their subsequent dispersal to locations throughout Brazil is likely to cause the future appearance of new disease foci where potential vectors are present.

This paper presents the original biosystematic data collected during the 1970s from the Amazonia focus in Brazil, interpreted with the assistance of more recent taxonomic findings from other parts of the country, and correlates these to data from the Venezuelan part of the focus to produce the first comprehensive entomological overview for the Amazonia onchocerciasis focus as a whole. The paper thus provides a sound basis and recommendations for the further entomological studies anticipated in both countries under the control programme for human onchocerciasis in the Americas currently being coordinated by the World Health Organization.

THE AMAZONIA ONCHOCERCIASIS FOCUS

The Amazonia onchocerciasis focus straddling the border between Brazil and Venezuela is the most remote of the foci of Latin America (Map 1). It consists of isolated communities of infected Yanomami Indians in contrast to the larger aggregations of infected people seen in the more populated areas of most of the other foci in Latin America. It covers part of north-western Roraima and northern Amazonas State in Brazil, and south-eastern Amazonas Territory and southern Bolivar

State in Venezuela, and almost coincides with the area (about 200,000km^2) inhabited by Yanomami Indians. Few of the estimated 20,000 Yanomami indians have been examined, but generally the disease appears to be mainly hyperendemic (more than 60% prevalence rates and disease with pathogenic effects) in the highland central part of the focus and hypoendemic (less than 40% infection rates and disease having no social effects) in the lowland periphery as a result of different vector species (Godoy *et al.* 1989; Rassi *et al.*, 1977; Tada, 1983; reviews in Moraes *et al.*, 1979; Shelley, 1988a; Yarzabal *et al.*, 1985). The existence of two smaller foci in northern Amazonas Territory and southern Bolivar State of Venezuela figured in Basañéz & Yarzábal (1989) needs confirmation.

Communities (malocas) affected by onchocerciasis in the Brazilian part of the disease focus occur in most of the area occupied by Yanomami Indians, who numbered about 7000 in the 1993 census by the Ministry of Health. Although only six localities were visited, Yanomamis were often present on visits from inaccessible malocas and they were also examined. In most cases the Mission or FUNAI (National Indian Foundation) post is a medical centre serving several malocas in the area, some of which may be quite distant. In the 1970s the only area studied that was free of the disease was the Marari mission in the south (Rassi *et al.*, 1976a,b) but Yanomamis from the R. Cauabori and R. Marauiá to the southwest of that mission were not examined. These authors also recorded the absence of onchocerciasis in several localities to the east, outside Yanomami territory. More localities were studied for onchocerciasis prevalence than for vectors, and these are reviewed in Moraes *et al.* (1978, 1979, 1986). Sampling localities were limited by the availability of mission and FUNAI posts with landing strips for light aircraft. Brief details of the localities sampled during the present entomological work are as follows (see Map 1) (population estimates based on 1993 census, unless indicated otherwise):

Auaris – the Auaris mission post (4°00'N, 64°29'W) is the most northern of the localities sampled and is situated at the edge of the R. Auaris in a forested area at an altitude of 670m. Low prevalence rates (19% of 126) of onchocerciasis were found in 1976 in the Yanomami and Maiongong Indians in the area, whose population is now 912. Skin microfilarial densities then averaged less than 1 mf/mg. Infections with the non pathogenic filaria *Mansonella ozzardi* were also present (36.5% of 126). In the dry season the R. Auaris is 7m wide with a bottom of large rocks and mud, turbid water and a medium flow. The 2m wide creek, Igarapé Hutumati, has a medium flow on a muddy bottom and emerges from the forest to join the R. Auaris near the mission post. Both flood their banks and run faster during the rains.

Serra dos Surucucus – the FUNAI post (2°42'N 63°09'W) lies by a stream in a small savanna area surrounded by forest at an altitude of 800m. A high onchocerciasis prevalence of 95% (of 18) was recorded in 1977. A later survey reported in 1992 recorded a similarly high prevalence rate of 82.2% (of 169) and average skin microfilarial densities of 17.8 mff/mg (personal communication, Dr Marciano da Vila). The current population is 1358. Various small rivers and streams occur in this area in the dry season, the only locality in the focus where Roraima sandstone is present. The Igarapé Majeba emerges from forest, traverses the savanna by the FUNAI post and then again enters dense forest. It is 3–5m wide, shallow, and runs over rocks, sand and mud with a medium flow and several waterfalls. The other important water course, the Igarapé Falemu is about 2kms from the post, is 6m wide and has clear water flowing fast over rocks. It supplies water for a hydroelectric dam. Other water courses in the area are a shallow 1.5m wide forest stream with muddy water and medium flow close to the abandoned mission post; the shallow, 2m wide, slow flowing, clear Igarapé da Floresta in forest 1km from the FUNAI post; and a 5m wide, shallow, clear forest stream with slow flow at Dalem some 4 hours walk (15–20kms) from the FUNAI post. Numerous other water courses at some distance from the FUNAI post were not sampled.

Parimiu – This is a relatively new mission post (3°19'N 62°58'W) on the R. Uraricoeira in forest at an altitude of 300m. An onchocerciasis prevalence rate of 23% of 26 examined was recorded in 1977 in this population currently numbering 290. The river at this point is about 15m wide in the dry season with extensive rapids over rocks covered by Podostemaceae. No information is available on streams in the area.

Mucajai – the Mucajai mission post (2°45'N, 62°14'W) is on the banks of the R. Mucajai in forest at an altitude of 200m. Onchocerciasis prevalence was low on the first survey in 1977 (7.6% of 65 examined) and again (3.1% of 63 examined) 7 years later in a population then of 366. The R. Mucajai 400m downriver from the mission is 50m wide, rocky with rapids, turbid water and submerged vegetation and Podostemaceae (broad leaved and strap-leaved species) growing on rocks. A 5m wide stream, the Igarapé Coroconai, emerges from the forest and joins the river at the rapid.

Catrimani – the Catrimani mission post (1°45'N, 62°17'W) is at an altitude of 230m in forest close to the R. Catrimani, a short distance from the Northern Perimeter Road. Onchocerciasis prevalence was low (8.3% of 36 examined) in 1977 and the disease was not detected in local Indians 7 years later (0% of 49 examined). The Yanomami population is currently

401. During the dry season (January 1979) the river was low, about 50m wide, fast flowing, exposing large rocks with species of Podostemaceae attached to the sides and providing a habitat for simuliids. In the wet season the rapids and forest become inundated and preclude sampling. No local streams are present.

Toototobi – the Toototobi mission post (1°45'N, 63°37'W) is situated alongside the R. Toototobi at 180m altitude in dense forest in the south of the focus, close to the border with Venezuela. A prevalence rate of 91.7% of 97 Indians examined and average skin microfilarial densities of 14.2 in the buttock and 5.8mff/mg in the shoulder regions were recorded in 1976. The current population is 627. Indians from here regularly visit villages in Venezuela (R. Unguetu and R. Siapa). The river here is about 12m wide with medium flow over rocks and mud, which sometimes become exposed during long dry seasons. In the wet season the river floods the forest. A stream runs through the forest close to the mission post.

In Venezuela, onchocerciasis was found in Yanomami villages at three main locations, the headwater region of the R. Orinoco (in the Parima mountain range and adjoining lowland forest), the Siapa river basin of the R. Negro near the Serra de Unturán in the Federal Territory of Amazonas, and in the upper R. Caura region in Bolivar State (Basáñez & Yarzabal, 1989; Godoy *et al*,. 1989; Rassi *et al*., 1977; Tada, 1983). In the first area onchocerciasis was found in several Yanomami villages in highland savanna in the Parima mountains at two mission posts named Parima A (1050m) and Parima B (950m), in villages near the Orinoquito (Coyowa-teri) mission post in the forested foothills of the Parima mountains by the R. Orinoquito (250m), and at mission posts in lowland tropical forest (100–150m) at Platanal and Boca de Mavaca. Yanomami Indians further down the Orinoco at Boca de Ocamo and Tama Tama mission posts were free of the disease. Prevalence rates of onchocerciasis were over 70% and skin microfilarial densities were high (mean of 50.3mff/mg of skin) in Coyowa-teri and Parima A and B; both prevalence rates (50% and below) and skin microfilarial densities (no densities given) were lower in the lowland forested areas. Mansonelliasis occurred at low prevalence levels in the Parima area (Beaver *et al.*, 1976; Botto *et al.*, 1983). A low prevalence rate of onchocerciasis (50% of 40) and low skin microfilarial densities (2.9 per biopsy) of onchocerciasis were recorded from the Siapa basin. A survey of 30 villages in a 700km wide strip across Bolivar State showed the presence of onchocerciasis only amongst seven villages of Yanomami Indians living in a forested, highland region (600–900m) of the Upper Caura river area near the Pacaraima mountains north of the Brazilian border. Prevalence rates varied from 9–85% and skin microfilarial densities from 3.2–18.3/mg. *Mansonella ozzardi* is commonly found in high densities in the blood and skin snips and *Microfilaria bolivarensis* is also present (Godoy *et al.*, 1980a,b, 1989).

The region in which the focus lies is one of the most isolated in Amazonia and because of its inaccessibility its geology, local climate and flora and fauna are little known. Huber *et al.* (1984) summarise available data on the geology, soils, climate and give details of surveys of the vegetation of the Parima mountain watershed, from which the headwaters of the R. Orinoco in Venezuela and the R. Branco in Brazil arise. The main part of the Parima and Urucuzeiro ranges that divide Venezuela from Brazil lies between 800 and 1200m; various smaller ranges occur between this and lowland areas (around 100m) in Brazil. The Parima mountain range consists largely of granite intrusions in an underlying Guayana Shield basement. In Brazil these are largely alkaline from the R. Auaris in the north to the R. Mucajai, while from south to the Urucuzeiro mountains of Amazonas state acidic granite and gneiss are present; no Roraima sandstone formations occur but are present in the adjacent, lower mountain ranges of Surucucus and Uafaranda. Two types of soil predominate in the Brazilian part of the focus: shallow lithosols and red-yellow podsols of low fertility and high alumina content in the uplands, and red-yellow podsols mixed with lithosols and diastrophic red-yellow latosols in the lowlands.

No accurate climatic data are available for every part of the area; those available are mainly from Venezuela. Many data are conflicting, but the main trends are as follows. The climate of the Parima mountains is of the Monsoon type characterised by high rainfall for 8–10 months and low rainfall, at the beginning of the year, for 2–3 months, a generally isothermic temperature regime, and predominant wind direction from the E to NE (trade winds) in the drier season and from S to SE (intertropical convergence) for the rest of the year. In the Parima mountains of Venezuela rainfall is lower than in other parts of the region and occurs throughout the year, but shows a biseasonal pattern with more rain (above 100 mm per month) between March and October/November and less (around 50 mm), or sometimes no rain, from December to February. Lowland areas in Venezuela show a non-seasonal tropical lowland rainfall pattern where no month has less than 100 mm of rainfall. Savannas are present in humid premontane forest in the two Parima areas with annual rainfall of 1100–1200 mm and an average temperature range of 18–24°C. At Orinoquito the very humid tropical forest has an annual rainfall of 3750–5000 mm and an average temperature of 26°C. On the Brazilian side of the focus there is an increase in annual rainfall from 1500 mm in savanna areas around Boa Vista to more than 2000 mm in the mountainous areas of the Surucucus and upper Uraricoeira river near Auaris. Average

monthly temperature maxima and minima show little variation, maxima being similar in both mountainous and lowland areas but minima being lower at the higher altitudes (Venezuela: Parima mountains average maximum temperature 28°C, minimum 16°C, lowland locality maximum 31°C, minimum 22°C). At Tootobi data from missionaries indicate that climate varies annually, clearly illustrated by the great variation in river depth from one year to another (Fig. 266). The wet season usually extends from April to September but in 1978 and 1979 rainfall was very low in the wet season.

The vegetation in the Venezuelan Parima mountains in areas of acidic quartz and igneous outcrops is similar to that of the Guayana Highlands although containing more widespread neotropical taxa. Some species occur uniquely in parts of the range. The lack of uniformity of the flora is attributed to the differences in altitude, soils and water courses in the area. In the Brazilian Parima mountains, vegetation has been divided into the following types: submontane forest on Terra Firme (600–1000 m), similar in species composition to the adjacent Guayanan-Amazonian lowland forest except for white sand formations with vegetation similar to areas of the R. Negro, e.g. Auaris; montane cloud forest above 1000m; summit and outcrop floras at high altitudes with cloud forest and shrubby vegetation; river margins with common riverine Amazonian species; and savanna found only in the Serra dos Surucucus. This area is particularly interesting because it has Roraima sandstone formations and is composed of montane forest and a small area of savanna and is classified as a refuge for several plant families.

MATERIAL AND METHODS

Sampling of adult simuliids attracted to Yanomami volunteers, and of immature stages from breeding grounds, approached by foot or canoe, was carried out at the localities indicated below, but several major constraints hindered collections at many of the sites. Logistical difficulties were enormous: the expense of getting to the study area by aircraft was a major constraint for seasonal sampling; the lack of motorised canoes and roads restricted prospecting of immature stages to the environs of the mission or FUNAI post; the communication problem with Yanomami Indians unable to speak Portuguese precluded more intense sampling on biting habits; and the lack of facilities, such as electricity and housing severely restricted microscopic work in the field.

Collections to show seasonal trends were made at Tootobi and to a lesser extent at Auaris and Catrimani. Dates of collection and season were as follows:

Auaris – July 1986 (wet season), March 1977 (dry/wet season transition). Biting catches were made to determine *O. volvulus* infectivity rates and the biting behaviour of anthropophilic species. Experimental infections (see below) were carried out to determine which anthropophilic simuliid species are potential vectors of *O. volvulus*. Immature stages of simuliids were collected from the R. Auaris and the Igarapé Hutumati.

Serra dos Surucucus – May 1982 (rainy season), December 1986 (dry season). No biting catches were carried out here but the following streams (igarapés) were sampled for immature stages: Igarapés Majeba, Falemu, da Floresta, and unnamed streams at the abandoned mission post and Dalem.

Mucajai – January 1977, (dry season) July 1984 (wet season). Day long biting catches were not carried out. The R. Mucajai and the Igarapé Coroconai were sampled for immature stages.

Catrimani – January 1977 (dry), January 1979 (dry), July 1984 (wet season). Biting catches and experimental infection studies were carried out to determine biting behaviour, parous and infection rates. Immature stages were collected in the R. Catrimani.

Tootobi – December 1975 (wet season), February 1976 (wet/dry season), August 1976 (dry season), October 1976 (wet season), December 1976 (wet season), August 1977 (dry season), December 1977 (dry season). Biting catches were made to determine biting behaviour, parous and infection rates. Anthropophilic flies were experimentally infected with *O. volvulus* to determine the potential vector species. Immature stages were collected from the R. Tootobi and an unnamed Igarapé near the mission post.

Biting catches using Yanomami volunteers were carried out at most localities to determine species biting man, preferential biting sites on body, biting times and to provide material for parity and infection rate studies. Methods for collecting and data analysis are described in Shelley *et al.* (1982) and dissections for parity followed the methods of Lacey & Charlwood (1980).

The methodology for experimental infection of anthropophilic species to determine potential vectors is given in Shelley & Arzube (1985). Dissections for experimental and natural infection rates were made of alcohol preserved flies (that had not been scored for parity in natural infection studies) using the method described in Nelson (1958). No domestic animals except chickens and dogs were kept at the mission and FUNAI posts in Brazil so host preference studies were not attempted.

Collections of immature stages were made in a

variety of water courses of which the following were the most common types: shaded forest streams & savanna streams, rapids in large rivers with species of Podostemaceae growing on submerged rocks, slow to medium-flowing rivers with beds of mud, rocks or sand and waterfalls.

Observations in the paper are largely based on specimens deposited in The Natural History Museum, (formerly the British Museum (Natural History)), London, UK; all species are also represented in the collections at the Instituto Oswaldo Cruz (Departamento de Entomologia), Rio de Janeiro, Brazil. Material has been conserved as follows: larvae, pupae, individually reared adults with their pupal pelts and females from biting catches-in 80% alcohol; individually reared adults in association with their pupal pelts (in glycerine in small polypropylene phials) and females from biting catches-in the pinned collections; all stages on microscope slides in Berlese mountant; individually reared adults and man-biting females tested for cuticular hydrocarbons-preserved dry; chromosomal preparations from larval silk glands on microscope slides with accompanying photographs of some of the karyotypes, larval cadavers-on microscope slides or in 80% alcohol. Descriptions of adult coloration for each species have been based on pinned specimens while colour plates are from both pinned and alcohol preserved material, prepared according to the technique detailed in Shelley *et al.* (1989). Scutal patterns of *S. rubrithorax*, *S. oyapockense* and *S. roraimense* vary with direction of illumination. For each of these species descriptions of scutal patterns are given with the main light source in either an anterior or posterior position. Each specimen was arranged as follows: dorsal surface parallel to the microscope stage, with a diffuse background light to the left of the observer (at about 7 o'clock and shining on to the whole specimen and sufficiently bright to prevent shadow formation) and a focussed fibre optic light placed either anterior or posterior to the specimen on the same horizontal plane as the microscope stage.

Most measurements were made using a camera lucida, later replaced by an image analysis system (Kontron Elektronik Videoplan with a Zeiss Axioskop 20 and an SV6 microscopes). Body lengths for all life stages were measured from material in a lateral position maintained in glass beads within a watchglass containing alcohol (or Carnoys fixative in the case of some larvae). Gill and wing dimensions were measured from specimens in alcohol or slide mounted. Points of measurement (Fig. 1) were as follows:

Adults

Body length – a curved line drawn from the frons to the tip of the genitalia.
Wing length – a straight line drawn from the most distal point of the wing to the mid- point on a line drawn from the base of the costal vein to the base of the wing on its posterior margin.
Wing width – a straight line drawn at the widest point between the anterior and posterior margins.

Pupa

Cocoon length dorsally – a curved line from the anterior margin to the posterior point of attachment to the substrate with the cocoon lying in a lateral position.
Cocoon length ventrally – a straight line from the anterior to posterior points of attachment of the cocoon to the substrate.
Pupa length – a straight line from the frons to the posterior end of the abdomen with the venter uppermost.
Gill length – a curved line along the longest unbroken filament from its distal tip to the base of the main gill trunk at its junction with the thorax.

Larva

Body length – a curved line from the base of the posterior circlet to the point of attachment of the mandible to the head capsule with the larva in a lateral position.
Head capsule length – a straight line from the posterior margin to the most anterior point of the cephalic apotome.
Head capsule width – a straight line between the lateral margins at the widest point (always in the posterior half).

Terminology of structures in adults, pupae and larvae follows Shelley *et al.* (1989). At the beginning of each species description the following information regarding the original description and subsequent synonymies is given: *species or synonym name*, author, date of publication: first page on which description occurs, primary type and sex, collection locality, date of collection, (*collector*), (current depository), [details of synonymy]. Names in previously published works that are misidentifications or junior synonyms are referred to in this paper by the species name used in the systematics section. Table 4 provides a list of names used for these species in previous publications.

The following acronyms are used for depositories of specimens referred to in this paper.

BMNH	The Natural History Museum, London, U.K.
DDSV	Seccion de Oncocercosis, Division de Dermatologia Sanitaria, Villa de Cura, Aragua State, Venezuela.
DERM	Laboratorio de Entomologia de la Division de Endemias Rurales, Maracay, Aragua State, Venezuela.
ESUCV	Escuela de Ciencias, Universidad Central de Venezuela, Venezuela.

FSPUSP	Instituto de Higiene, São Paulo, Brazil.
IND	Instituto Nacional de Dermatologia, Villa de Cura, Aragua, Venezuela
IOC	Instituto Oswaldo Cruz, Rio de Janeiro, Brazil
IP	Institute Pasteur, Paris, France
INPA	Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil.
NMV	Naturhistorisches Museum, Vienna, Austria.
SMT	Staatliches Museum für Tierkunde, Dresden, Germany.
STMPR	Department of Microbiology, School of Medicine, School of Tropical Medicine, San Juan, Puerto Rico.
USNM	United States National Museum, Washington, D.C., U.S.A.
ZMHU	Zoologisches Museum der Humboldt-Universität, Berlin, Germany.

Full data for the very extensive material on which this work is based are given in Appendix 1 (p. 95) and this should be consulted for geographical information.

Voucher specimens of *O. volvulus* infective larvae mounted in Berlese on slides have been deposited in the World Health Organization Collaborating Centre for the Filarioidea, International Institute of Parasitology, Winches Farm Lane, St Albans, Hertfordshire, U.K.

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KEYS TO THE SIMULIID SPECIES OF THE AMAZONIA ONCHOCERCIASIS FOCUS OF BRAZIL

These keys have been constructed to facilitate rapid identification where possible. Morphological features that are easily damaged (e.g. scales) are not generally used, the main characters being easily observed in undissected material wherever possible.

The key functions for the fourteen species that occur in the Brazilian part of the Amazonia focus. It can be used as a starting point only for identification of species in the Venezuelan zone of the focus, but it should be noted that there the following species occur also: *beaupertuyi, covagarciai, matteabranchia, morae, parimaense* and *perflavum*. Descriptions of these species are given in Ramírez Pérez (1983) and Ramírez Pérez *et al.* (1982, 1984, 1986).

Females

1 Scutum orange or brown 2

– Scutum black 6

2 Scutum with pattern 3

– Scutum without pattern 5

3 Scutum brown with median and pair of lateral vittae and lateral margins silver pruinose (anterior illumination) (Colour Plate 1, Fig. 18) ..... ***rubrithorax***

– Scutum orange with white vittae or cunae 4

4 Scutum with pair of anterior, submedian, silver cunae (Colour Plate 2, Fig. 30) ..... ***bipunctatum***

– Scutum with pair of submedian silver vittae running from anterior to posterior borders (Colour Plate 2, Fig. 31) ..... ***iracouboense***

5 Paraproct large, three times length of cercus (Fig. 99). Cibarium with 1+1 groups of sharp, submedian teeth (Fig. 55) ..... ***rorotaense*** and ***suarezi****

– Paraproct small, twice length of cercus (Fig. 98). Cibarium with blunt tubercles in median and submedian areas, 1 + 1 groups of fine, sharp teeth at base of cornuae (Fig. 54) ..... ***lutzianum***

6 Scutum with silver pruinose areas 7

– Scutum without silver pruinose areas 11

7 Scutum mainly black with only humeri, lateral and posterior margins silver pruinose (Colour Plate 2, Fig. 35) ..... ***goeldii***

– Scutum black with silver pruinose pattern on dorsum 8

8 Scutum with pair of submedian silver pruinose cunae in anterior half of scutum [posterior illumination] 9

– Scutum with pair of submedian silver pruinose bands joining pruinose anterior and posterior margins [posterior illumination] 10

9 Nudiocular area absent (Fig. 38). Cibarium unarmed (Fig. 49) ..... ***cauchense***

– Nudiocular area present (Fig. 40). Cibarium armed (Fig. 51) ..... ***incrustatum***

10 Submedian silver bands fine and diverging posteriorly; black areas are [pattern consistent irrespective of illumination]: median, drop-shaped vitta and pair of wide, submedian vittae;anterior intervittal cunae in silver bands absent (Colour Plate 1, Fig. 21) ..... ***quadrifidum***

– Submedian silver bands wide; black areas are: [with anterior illumination] median vitta widening posteriorly, pair of disc-shaped areas between median vitta and lateral scutal margins and pair of anterior, comma-shaped marks in submedian silver bands; [with posterior illumination] disc-shaped black areas extend to anterior scutal border and comma-shaped marks in submedian silver bands appear silver (Colour Plate 1, Figs 23, 24) ..... ***oyapockense*** and ***roraimense***

11 Nudiocular area absent (Fig. 37). Paraproct broadly rectangular with pointed, anteriorly-directed process (Fig. 92) ..... ***exiguum***

– Nudiocular area present (Fig. 45). Paraproct broadly rectangular with tail-like projection pointing inwards (Fig. 100) ..... ***guianense***

* based on description by Ramírez Pérez *et al.* (1982)

Males

1 Scutum orange or orange-brown 2

– Scutum black 6

2 Scutum orange-brown, pair of faint, silver triangles extending into fine vittae in anterior half of scutum [posterior illumination] (Colour Plate 3, Fig. 113). Scutellum brown ..... ***rubrithorax***

– Scutum orange, with or without dorsal pattern. Scutellum orange 3

3 Scutum with silver dorsal pattern 4

– Scutum without pattern* 5

4 Scutum with pair of anterior, submedian silver or yellow cunae (Colour Plate 4, Fig. 124) ..... ***bipunctatum*** and ***suarezi***

– Scutum with pair of submedian silver bands running from anterior to posterior border (Colour Plate 4, Fig. 125) ..... ***iracouboense***

5 Ventral plate as wide as long, with small keel (Fig. 154) ..... ***lutzianum***

– Ventral plate longer than wide, with elongated keel (Fig. 155) ..... ***rorotaense*** and ***suarezi***

6 Scutum with silver pruinose dorsal pattern [posterior illumination] 7

– Scutum without silver pruinose dorsal pattern 11

7 Pair of silver pruinose bands connecting anterior and posterior margins of scutum [posterior illumination] 8

– 1+1 submedian, silver pruinose, comma-shaped or triangular markings in anterior half of scutum [posterior illumination] 9

8 Scutum with silver pruinose bands arising in submedian region of anterior margin and with antero-median, comma-shaped mark (black with anterior and silver with posterior illumination) (Colour Plate 3, Fig. 120) ..... ***roraimense***

– Scutum with silver pruinose bands arising in area below humeri on lateral margins and without comma-shaped mark (Colour Plate 4, Fig. 129) ..... ***guianense***

9 Submedian, silver pruinose, triangular markings large; at least 2/3 as wide as long at anterior margin and extending from anterior margin for 1/2 to 2/3 of thorax length and sometimes extending as fine lines almost to silver posterior margin (Colour Plate 3, Figs 117, 118, 119) ..... ***oyapockense***

– Submedian, silver pruinose, comma-shaped marks small; at maximum 1/3 as wide as long at anterior margin .. 10

10 Abdomen with prominent pruinose patch at lateral margins of eighth tergite ..... ***cauchense***

– Abdomen without prominent pruinose patch at lateral margins of eighth tergite (Colour Plate 3, Figs 115, 116) ..... ***quadrifidum***

11 Scutum with groups of short, wide, iridescent golden or green setae, especially on anterior half 12

– Scutum with numerous recumbent, silver or golden hairs but lacking groups of wide setae 13

12 Only posterior scutal margin faintly pruinose (Colour Plate 3, Fig. 114). Gonostyle with inconspicuous spine (Figs 133, 134, 135) ..... ***exiguum***

– Lateral and posterior scutal margins obviously pruinose (Colour Plate 3, Fig. 121). Gonostyle with well developed spine (Fig. 139) ..... ***incrustatum***

13 Gonostyle broad at base tapering gradually in distal half (Fig. 136) ..... ***quadrifidum***

– Gonostyle narrow at base and becoming narrower in distal third (Fig. 146) ..... ***goeldii***

* The yellow comma-shaped marks in male *S. suarezi* are sometimes absent.

Pupae

1 Gill fan-shaped, with 18–20 filaments 2

– Gill not fan-shaped, with 4–12 filaments 3

2 Filaments arising in pairs or singly in basal 1/6 of gill from dorsal and ventral primary branches (Fig. 207) ..... ***rorotaense***

– Filaments arising in pairs or singly from expanded base of gill (Fig. 208) ..... ***suarezi***

3 Gill with 12 filaments (Fig. 209) ..... ***guianense***

– Gill with less than 12 filaments 4

4 Gill with 8 filaments 5

– Gill with less than 8 filaments 10

5 Cocoon shoe-shaped and with anterior festoons obscur-

ingcephalothorax of pupa (Fig. 180) ..... ***rubrithorax***

– Cocoon slipper-shaped, cephalothorax of pupa partly exposed 6

6 Gill filaments fine and flimsy; main trunk dividing basally to form two primary branches (Fig. 210) .. ***goeldii***

– Gill stout and rigid; main trunk dividing basally to form three primary branches 7

7 Gill filaments bunched together, depth at most distal bifurcation less than maximum depth of cephalothorax (Fig. 206) ..... ***lutzianum***

– Gill filaments splayed out, depth at most distal bifurcation more than maximum depth of cephalothorax 8

8 Ventral primary branch of gill almost parallel to anterior edge of cephalothorax (Fig. 203) ..... ***bipunctatum***

– Ventral primary branch of gill at right angles to anterior edge of cephalothorax (Figs 192, 204) 9

9 Transverse rings on filaments highly accentuated (Figs 192, 193) ..... ***exiguum***

– Transverse rings on filaments faint (Fig. 204) ..... ***iracouboense***

10 Gill with 6 filaments 11

– Gill with 4 filaments 13

11 Gill long, at least 1.5 times pupal length (Fig. 198) ..... ***incrustatum***

– Gill short, approximately length of pupa (Figs 196, 197) 12

12 Thoracic platelets mainly rounded. Tergite II with or without 1+1 patches of antero-lateral spine combs, tergite III with such spine-combs (Fig. 211) ..... ***oyapockense***

– Thoracic platelets mainly pointed. Tergites II and III without spine-combs (Fig. 212) ..... ***roraimense***

13 Primary branching of gill in horizontal plane; gill branches usually bifurcate at same level in basal 1/5 of gill; abdominal tergite V with weak submedian row of spines (usually present) along anterior border terminating in weak patch of spine combs at margins (Fig. 194) ..... ***quadrifidum***

– Primary branching of gill in vertical plane; gill branch bifurcations usually not at same level at mid point of gill; tergite V without spines or spine combs (Fig. 195) ..... ***cauchense***

Larvae

Two important characters used in identification of larvae of Neotropical species are the head spot pattern and body coloration. Both these characters are now known to show considerable variation in both *S. exiguum s.l.* and *S. guianense*. This key should be used taking into consideration that extensive variation in these characters could also be present in other species, particularly where long series of specimens are being examined. The key applies to mature larvae with fully developed gill histoblasts.

1 Body uniformly dark, length more than 10 mm (Fig. 213) ..... ***rubrithorax***

– Body light with dark bands, length less than 7 mm ... 2

2 Cuticle surface smooth with numerous setae mainly on dorsal surface 3

– Cuticle surface smooth with occasional setae 7

3 Setae on thorax and abdomen large and platelet-shaped (Figs 14, 222) ..... ***guianense***

– Setae on thorax and abdomen small and pointed (Fig. 13) 4

4. Ventral papillae present (Fig. 217) 5

– Ventral papillae absent (Fig. 220) ..... ***lutzianum***

5. Abdomen with prominent dark bands on first four segments. Head pattern strongly positive or negative (Figs 217, 229, 230) ..... ***incrustatum***

– Abdomen with no dark bands on first four segments, or with first segment only with prominent dark band. Head pattern absent or faintly positive 6

6. Ventral papillae large (Fig. 215) ..... ***cauchense*** and ***quadrifidum***

– Ventral papillae small (Fig. 216) ..... ***oyapockense*** and ***roraimense***

7. Postgenal bridge highly reduced or absent (Fig. 243) ... ***bipunctatum***

– Postgenal bridge well developed (Fig. 239) 8

8. Abdomen with prominent dark bands on four anterior narrow segments (Fig. 214) ..... ***exiguum***

– Abdomen without obvious bands on four anterior narrow segments or with only band on first segment prominent (Fig. 219) 9

9. Head pattern negative in form of circle with crenated outer border (Fig. 232) ..... ***iracouboense***

– Head pattern absent or slightly positive 10

10. Mandible with antero-lateral process fleshy and forked (Fig. 260) ..... ***goeldii***

Mandible without antero-lateral process .... ***rorotaense***

SPECIES DESCRIPTIONS

Simulium (Hemicnetha) rubrithorax Lutz

(Colour Plate 1, Figs 18,19; Colour Plate 3, Fig. 113; Figs 36, 47, 58, 69, 80, 91, 102, 132, 147, 158, 169, 180, 191, 213, 224, 238, 249)

Simulium rubrithorax Lutz, 1909: 132. NEOTYPE ♀, BRAZIL: Minas Gerais State, Juiz de Fora, 43°22'W 21°47'S, 10.x.1909 (*C. Chagas*) (IOC) by desig-nation of Maia-Herzog *et al.* (1984: 352). [LECTOTYPE ♀ designation of Vulcano (1958) invalid as not from syntype series (Maia-Herzog *et al.*, 1984)]

Simulium magnum Lane & Porto, in Porto 1940: 383. HOLOTYPE ♀, BRAZIL: Mato Grosso, Chapada, Ponce, 600m, viii.1934 (*J.Lane*) (FSPUSP). [Synonymy by Py-Daniel, 1989: 255.]

This well known species was only collected in the larval stage in the onchocerciasis focus. The description below is therefore based on material collected here and from other parts of Brazil deposited in the BMNH and IOC and noted under Material Examined.

FEMALE. General body colour orange/brown and black. Body length 3.4–4.5 mm (n=2); wing length 3.2–4.6 mm ($\bar{x}$=3.8 mm, s.d.=0.4, n=18), wing width 1.4–1.9 mm ($\bar{x}$=1.7 mm, s.d.=0.4, n=16).

Head dichoptic with red eyes showing golden highlights; nudiocular area well developed (Fig. 36). Frons, clypeus and occiput dark brown with silver pruinosity; frons with numerous, irregularly arranged, stout hairs predominantly on margins. Mouthparts and maxillary palps dark brown. Antennae brown with scape, pedicel and basal third of first flagellomere yellow. Cibarium unarmed with slight trough, lightly sclerotised margin and highly sclerotised cornuae (Fig. 47).

Scutum predominantly orange-brown with numerous recumbent golden hairs. Scutal pattern varying in appearance with illumination. With anterior illumination, thorax dark brown with following areas grey-silver pruinose: wide median vitta originating as triangle with base on anterior margin, expanding to drop-shape extending for nine tenths of scutum, divided longitudinally by fine, dark brown line; pair of lateral vittae beginning at anterior fifth of scutum and extending for nine tenths of its length; lateral border of scutum (Colour Plate 1, Fig. 18). With posterior illumination grey pruinose and brown areas become reversed, the previously pruinose vittae appearing dark brown and the dark brown background silver-grey pruinose; posterior margin greyish black (Colour Plate 1, Fig. 19). Humeri orange-brown. Paranotal folds dark brown with silver pruinosity. Pleural region dark, mottled orange-brown with grey pruinosity; prominent patch of long, golden hairs on pronotum; pleural tuft of prominent, golden hairs. Scutellum mid brown with light pruinosity and numerous, long, recumbent, golden hairs and long, dark hairs on outer margins. Postnotum dark brown with grey pruinosity.

Subcostal wing vein with row of 4–6 setae in basal half; many sensilla in basal area. Basal quarter of R bare; following quarter with irregular row of predominantly (or solely) fine setae; next quarter with irregular row of both fine and stout setae; distal quarter with regular row of mainly stout setae (total of 40–48 fine setae and 22–25 stout setae) (Fig. 58). Costal base tuft of dark hairs.

Legs yellow with following dark areas (Colour Plate 1, Fig. 18): fore leg with distal sixth of femur, basal quarter and distal fifth and outer margin of tibia, basitarsus and tarsi dark brown; mid leg with coxa, distal sixth of femur, distal quarter, sub-basal spot and outer margin of tibia black; distal two fifths of basitarsus and tarsi dark brown; hind leg coxa black, distal quarter of femur all of tibia except basal articulation and median quarter, distal half of basitarsus black; distal half of first tarsomere and remaining tarsi dark brown. Claws curved with large basal tooth (Fig. 69). Halteres pale yellow with slightly darkened stems.

Abdominal tergites predominantly black, but mottled orange-brown (Colour Plate 1, Fig. 18); basal scale (tergite I) velvet yellow/black with fringe of long golden hairs; tergite II velvet black with anterior half mottled with rust coloured patches; tergites III–IV velvet-black; tergites V–IX shiny black. Tergal plates sclerotised as in *S. exiguum* (Fig. 5). Sternites mid to pale brown. Genitalia brown. Eighth sternite with well sclerotised central plate and 1+1 groups of 11–13 well developed setae; gonopophyses large and well developed, subtriangular, covered in setae with some sclerotisation on lower surface (Fig. 80). Cerci hemispherical but slightly flattened on outer surface; paraprocts subtriangular and extremely large (about 2½ times as wide as cerci) extending well below cerci (Fig. 91). Genital fork (Fig. 102) highly sclerotised with long vertical anterior process, area encompassed by lateral arms relatively narrow, end of stem spatulate. Spermatheca oval, strongly sclerotised, without external sculpturing and spicules in rows; width of membranous area of insertion of spermathecal duct small, about quarter maximum width of spermatheca.

MALE. General body colour mottled orange-brown and black. Body length 4.0–5.1 mm (n=2); wing length 2.6–3.8 mm ($\bar{x}$=3.4 mm, s.d.=0.4, n=9); wing width 1.3–1.9 mm ($\bar{x}$=1.6 mm, s.d.=0.2, n=9).

Head holoptic with upper eye facets red and lower eye facets dark red (appearing black in dried specimens). Rest of head coloration as in female.

Scutum orange-brown with some black areas and silver pruinosity; numerous recumbent, golden hairs (Colour Plate 3, Fig. 113). Lateral margins and posterior quarter of scutum silver pruinose. Scutum with no pattern, anterior margin grey pruinose with anterior illumination. Scutum with pair of small, faint silver triangles on anterior margin joining pair of submedian narrow silver vittae running to middle of scutum with posterior lighting. Black areas around humeri and central third of scutum. Humeri orange-brown. Col-

oration and setation of paranotal folds, pleural region, scutellum and postnotum as in female.

Subcostal wing vein as female. Basal quarter of Radius bare, remainder with irregular row of 22–25 stout setae interspersed with several fine setae.

Leg and halter coloration as in female (Colour Plate 3, Fig. 113).

Abdominal tergites mainly velvet black, slightly mottled, genitalia light brown. Tergite I mottled yellow and black with fringe of long pale hairs. Silver ornamentation as follows: tergite II with anterior border silver pruinose and 1+1 large, silver, pruinose spots occupying five sixths of lateral area; tergites VI–VII with 1+1 relatively large, distinct, lateral, pruinose spots; remaining tergites with 1+1 small, pruinose, antero-lateral spots (Colour Plate 3, Fig. 113). Sternites pale brown with poorly developed sternal plates. Gonocoxite rectangular, one and a half times as wide as long; gonostyle elongate, over twice as long as wide, and slightly 'S' shaped with weakly developed subterminal spine (Fig. 132). Ventral plate well developed with large protruding keel densely covered with long setae (Fig. 147). Median sclerite elongate, subtriangular, narrow at base (Fig. 158). Paramere with large basal process and two distinct clusters of stout spines, sub-median with about 20 spines, lateral with slightly fewer spines and extending to basal process (Fig. 169).

PUPA. Cocoon length dorsally 3.4–5.2 mm ($\bar{x}$=4.3 mm, s.d.=0.6, n=25); ventrally 4.1–6.1 mm ($\bar{x}$=4.9 mm, s.d.=0.5, n=25); pupa length 3.1–4.9 mm ($\bar{x}$=4.0 mm, s.d.=0.4, n=25); gill length 2.5–5.4 mm ($\bar{x}$=3.2 mm, s.d.=0.6, n=25).

Cocoon shoe-shaped, mid to pale brown with obvious collar and long, slender festoons joined to form a loose lattice (Fig. 180). Cocoon surface smooth and translucent, with no individual fibres visible.

Gill light brown, protruding slightly beyond festoons, with eight forwardly-directed filaments (Fig. 191). Main trunk dividing basally into two primary branches each with four filaments. All filaments arise in basal quarter of gill, are slender with only faintly crenated margins and rounded distally, their surfaces densely covered with fine spicules.

Head (frontoclypeus) with 1 + 1 small, simple, frontal trichomes and 1+1 poorly developed, simple facial trichomes. Frontal area lacking platelets but with sclerotised triangular area surrounded by irregular row of small sclerotised plates extending from anterior margin for one third length of fronto-clypeus. Facial area with numerous platelets arranged in regular rows towards margin.

Thorax well sclerotised with faint ring of small plates loosely arranged around gill base (predominantly on dorsal side). Antero-dorsal surface with 5 + 5 (or 6 + 6) weakly developed trichomes, three of which usually lie in line midway between gill base and dorsal margin. Central antero-dorsal region with trichomes but no platelets, which are present only in patches on lateral and ventral areas.

Abdominal setation variable. Tergite I completely sclerotised with numerous spine combs occupying most of posterior third to half of tergite; tergite II sclerotised in anterior half, often with small plates, 1 + 1 rows of 2–3 coarse hairs centrally, 1 + 1 hairs at outer end of row (often absent), anterior third with spine combs interspersed with hairs; tergite III with 4 + 4 simple hooks centrally, 1 + 1 simple hairs antero-lateral to them (frequently absent) and 1 + 1 anterior patches of spine combs; tergites IV and V with 1 + 1 rows of 1–4 hooks usually present and 1 + 1 anterior patches of spine combs; tergites VI–VIII with 1 + 1 anterior patches of spine combs (extending to lateral margins in tergites VII–VIII); tergite IX with rounded apical tubercles not spines. Sternites III–IV with anterior band of spine combs; sternite V with 2 + 2 close, simple hooks and anterior band of spine combs, most prominent above hooks; sternites VI–VII with four evenly-spaced, simple hooks and anterior band of spine combs; sternites VIII–IX with central band of spine combs, often weakly defined in sternite IX.

MATURE LARVA. Body length 10.9–15.2 mm ($\bar{x}$= 12.7 mm, s.d.=1.0, n=30); width of head capsule 0.8–1.2 mm ($\bar{x}$=1.0 mm, s.d.=0.1, n=30); length of head capsule 0.9–1.3 mm ($\bar{x}$=1.1 mm, s.d.=0.1, n=30). Body colour grey in specimens preserved in alcohol. Form as in Fig. 213.

Head mainly dark brown, anterior region of cephalic apotome yellow. Numerous small setae present on all surfaces and head capsule slightly wrinkled. Head pattern positive (Fig. 224). Postgenal cleft narrow, bell-shaped with subtriangular extension at apex; postgenal bridge as wide as hypostomium (Fig. 238). Hypostomium rounded anteriorly with strongly pigmented anterior margin and nine apical teeth; median tooth sharp, well developed and most prominent; corner teeth and teeth directly adjacent to median tooth only slightly smaller and sharp, remaining teeth less well developed; 3–6 lateral serrations; 1 + 1 lines of 9–13 hypostomial setae parallel to lateral margin; 2 + 2 (rarely 3 + 3) setae in posterior half of hypostomium (Fig. 249). Antennae long and pigmented with segment ratios approximately 10:13:11. Mandible with second comb tooth longer than first and third; two mandibular serrations, posterior smaller than anterior; mandibular combs well developed. Maxillary palp heavily pigmented; three times as long as wide at base. Cephalic fan with 60–80 rays.

Thorax grey dorsally and ventrally. Cuticle without setae. Proleg (see Fig. 15) with plate heavily sclerotised with a band of over 60 processes. Pupal respiratory gill histoblast dark brown, claviform.

Abdomen usually completely grey dorsally, progressively paler ventrally, especially towards posterior where last segments white; faint segmental banding visible ventrally.

Ventral nerve cord grey. Ventral papillae absent. Cuticle mainly lacking setae except area around anal sclerite. Anal sclerite well sclerotised with posterior arms extending to 70–90th row of posterior circlet hooks, anterior arms bifid at apex; no sclerotised areas between arms. Posterior circlet with over 350 rows of up to 55 hooks. Anal gill trilobed, each lobe with 15–22 fine finger-like lobules of which one is slightly larger than rest.

Taxonomic discussion

This very characteristic species of the subgenus *Hemicnetha* has been reviewed by Coscarón (1991) and Maia-Herzog *et al.* (1984). It is most similar to *S. virgatum, S. paynei* and *S. bricenoi* from which it can be distinguished by the colour of the male scutum. The latter authors suggest further study to determine whether these names may refer to a single, widely distributed, polymorphic species.

In 1989 Py-Daniel synonymised *S. magnum* [as *S. major*] Lane & Porto with *S. rubrithorax* having examined the type material of the latter species. *Simulium magnum* was first published in 1940 (Porto, 1940) as part of a key to Neotropical Simuliidae and predates the description of the species as *S. major* by Lane and Porto (1940) later in the same year. Under the present (third edition) International Code of Zoological Nomenclature adjectival specific names must agree in gender with generic names: *Simulium* being neuter requires combination with the neuter *magnum* and not the masculine *major* (R.W.Crosskey, personal communication).

Distribution

This species has only been recorded at one location (Serra dos Surucucus) in the Brazilian part of the focus and has not yet been collected in the Venezuelan part (Tables 1 & 2). *Simulium rubrithorax* is a common species elsewhere in Brazil and to a lesser extent Argentina (Material Examined; Coscarón, 1991; Maia-Herzog *et al.*, 1984; Py-Daniel, 1989). The former two authors also record this species in Venezuela based on Lutz (1928), but Ramírez Pérez (1987) regards the latter record as a misidentification of *S. paynei*, having compared Lutz's material in the IOC to reared material collected at the same localities. Similarly, Coscarón (1991) records *S. rubrithorax* in Guyana, presumably based on Smart (1940). Although Smart identified his specimens as *S. rubrithorax* (from dissected pupae) his description of the pupa with 14–22 filaments on the gill as well as the collection locality suggested another species, *S. rorotaense*. Two slide preparations that were used for the 1940 description of *S. rubrithorax* by Smart in the BMNH collection (details of labels in Material Examined) have now been examined. One contains three males (without terminalia) dissected from their pupae and the other the terminalia of these males and all have now been identified as *S. rorotaense*.

Simulium (Notolepria) exiguum Roubaud

(Colour Plate 1, Fig. 20; Colour Plate 3, Fig. 114; Figs 2,4,5,6, 8, 9, 10, 11, 12, 16, 17, 37, 48, 59, 70, 81, 92, 103, 133, 134, 135, 148, 159, 170, 181, 192, 193, 214, 225, 226, 239, 250)

Simulium exiguum Roubaud, 1906: 108. LECTOTYPE ♀, VENEZUELA: Haut Sarare, 1899 (F.Geay) (MHNM) [Lectotype designation in Shelley *et al.*, 1989: 84]

Simulium glaucophthalmum Knab, 1914: 123. HOLOTYPE ♀, PERU: Santa Clara, iv.1914 (C.H.T.Townsend) (USNM Cat. No. 18494) [Synonymy by Wygodzinsky, 1951: 214]

Simulium delpontei Paterson & Shannon, 1927: 742. SYNTYPES ♀[incorrectly cited as HOLOTYPE in Shelley *et al.*, 1989], ARGENTINA: Salta Province, Embarcacion, 4.v.1926 (Paterson, Shannon & Shannon) (depository unknown) [Synonymy by Wygodzinsky, 1951: 214.]

Simulium urubambanum Enderlein, 1934a: 286. HOLOTYPE ♀, PERU: Rosalina, R. Urubamba, 28.viii.1903 (collector unknown) (ZMHU) [Synonymy by Coscarón, 1987: 20.]

FEMALE. General body colour black. Body length 1.6–2.6 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=44); wing length 1.4–2.0 mm ($\bar{x}$=1.8 mm, s.d.=0.1, n=44), wing width 0.6–1.0 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=44).

Head dichoptic with dark red eyes showing green highlights; nudiocular area absent (Fig. 37). Frons, clypeus and occiput black with silver pruinosity. Mouthparts orange-brown. Antennae dark brown with scape, pedicel and first flagellomere orange-brown. Cibarium unarmed (Fig. 48).

Scutum and humeri greyish black with faint silver pruinosity; one median and pair of submedian, darker black lines running along whole length of scutum and diverging posteriorly (best seen in females devoid of setae with illumination perpendicular to specimen); scutum with small velvet-black spot adjoining paranotal folds (=paratergites). Paranotal folds black with silvery grey pruinosity. Scutum with numerous, short, recumbent dark setae and discrete groups of short flattened brass-coloured setae with greenish reflections (Colour Plate 1, Fig. 20). Pleural region silvery grey, pruinose. Scutellum greyish black, faintly pruinose, vestiture of golden setae longer than those on scutum and single row of black bristles on posterior margin. Postnotum silvery grey, pruinose.

Subcostal wing vein and basal sector of Radius bare (Fig. 59). Costal base tuft of dark hairs.

Legs yellow to light brown, except fore tarsi, mid and hind coxae, hind femora and distal three-fourths of hind tibiae black (Colour Plate 1, Fig. 20). All femora and tibiae with scales (Fig. 4). Tarsi narrow (Fig. 2) and claws curved and slender, without basal tooth on fore and mid legs but with poorly developed tooth on hind leg (Fig. 70). Halteres pale yellow with light brown stem.

Abdominal tergites shiny, brownish black with silver pruinosity on second segment (Colour Plate 1, Fig. 20). Tergal plates well developed, pattern as in Fig. 5. Sternites brownish black; genitalia light brown. Eighth sternite highly sclerotised with 1 + 1 groups of 8–12 stout setae (Fig. 81); gonopophyses small, sclerotised on inner margin, glabrous. Cerci hemispherical, light brown; paraprocts broadly rectangular with pointed anteriorly directed process (Fig. 92). Genital fork (Fig. 103) slender, with sclerotised anteriorly directed processes and stem spatulate. Spermatheca oval, highly sclerotised, with no external sculpturing and spicules of inner surface obscured by sclerotisation; width of membranous area of insertion of spermathecal duct large, about half maximum width of spermatheca (Fig. 6).

MALE. General body colour black. Body length 1.6–2.4 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=17); wing length 1.2–1.8 mm ($\bar{x}$=1.6 mm, s.d.=0.1, n=15); wing width 0.6–0.9 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=14).

Head holoptic with dark red eyes; lower, smaller facets with greenish reflections. Clypeus black with silver pruinosity, other head coloration as in female.

Scutum and humeri velvet-black with posterior margin faintly silver pruinose. Paranotal folds velvet-black with silvery grey pruinosity. Scutum covered in numerous, short, recumbent, light brown setae interspersed amongst groups of brilliant gold, scale-like setae (Colour Plate 3, Fig. 114). Coloration and setation of pleural region, scutellum and postnotum as in female except scale-like setae on scutellum brilliant gold.

Wing venation, leg coloration (Colour Plate 3, Fig. 114) and halter coloration as in female.

Abdominal tergites velvet-black, basal fringe dark brown with few long hairs. Silver ornamentation as follows: tergites II and VI all silver except sometimes in median area on VI; tergite VII all silver except for median area, some specimens with 1 + 1 lateral silver pruinose patches on posterior margin of tergite VIII. Tergite IX shiny black (Colour Plate 3, Fig. 114). Sternites grey with well developed velvet-black sternal plates on segments II–VIII. Genitalia brownish black. Gonocoxite subrectangular; gonostyle small, subtriangular, one-third as long as gonocoxite and with small distal spine (Fig. 133). Spine size variable in different populations from Brazil (Fig. 134) and Ecuador (Fig. 135). Ventral plate with reduced basal arms, lightly sclerotised, triangular, with small keel, hairs short, diffuse and mainly occurring around median keel (Fig. 148). Median sclerite subrectangular with superficial apical incision (Fig. 159). Paramere with several apical spines (Fig. 170).

PUPA. Cocoon length dorsally 1.9–2.5 mm ($\bar{x}$=2.2 mm, s.d.=0.1, n=37); ventrally 2.1–3.1 mm ($\bar{x}$=2.6 mm, s.d.=0.2, n=37); pupa length 1.7–2.6 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=37); gill length 1.1–1.7 mm ($\bar{x}$=1.4 mm, s.d.=0.2, n=37).

Cocoon slipper-shaped, mid to dark brown; rim of aperture dark brown, reinforced and without central protuberance (Fig. 181). Cocoon composed of elastic, amorphous substance interwoven with fibres. Gill light brown with eight forwardly directed, slender filaments arranged in the vertical plane (Fig. 192), main trunk giving rise to three primary branches; ventral with two filaments and median and dorsal each with three filaments; ventral branch with bifurcation in basal fourth of gill, median branch with first bifurcation in basal fourth and second bifurcation in basal third of gill; dorsal branch with first bifurcation basally at junction of median and dorsal primary branches and second bifurcation within basal fourth of gill. Filaments slender, rounded distally, surfaces covered in fine spicules and prominent transverse ridges (Fig. 193). Head (frontoclypeus) with 2+2 frontal trichomes of which the more dorsal pair is simple and poorly developed and the more ventral pair well developed and 2–5 branched, and with 1+1 well developed facial trichomes with 2–5 branches; surface of head covered with platelets (Fig. 8). Thorax with 5+5 antero-dorsal, well developed trichomes of 2–5 branches (Fig. 9). Surface of thorax covered with platelets, which are more densely distributed on anterior half. Abdominal tergite II with 4+4 simple hairs in line on posterior border, III–IV with 4+4 simple hooks, VI–IX with patches of poorly developed spine combs on antero-lateral margins, IX with 1+1 strong, unbranched spines (Fig. 10); sternite IV with 1+1 simple hairs, V with 2+2 bifid or trifid hooks, VI and VII with 2+2 hooks, inner pairs being bifid or trifid and outer pairs simple; sternites IV–VIII with 1+1 patches of poorly developed spine combs on postero-lateral borders (Fig. 11).

MATURE LARVA. Body length 3.0–4.1 mm ($\bar{x}$=3.6 mm, s.d.=0.3, n=35); width of head capsule 0.3–0.5 mm ($\bar{x}$=0.4 mm, s.d.<0.1, n=35); length of head capsule 0.4–0.6 mm ($\bar{x}$=0.5 mm, s.d.<0.1, n=35).

Body colour usually white with greyish brown markings (Fig. 214), occasionally almost completely white and showing only indistinct grey pigmentation. Coloration in Carnoy's fixative similar except banding patterns more distinct. Body form as in Fig. 214.

Head yellow with head spots concolorous; occasional specimens with positive head spot pattern (Fig.

225) or with an amorphous dark area in head spot region that obscures the spots or more rarely a negative head pattern (Fig. 226). This variation, negative to positive, occurs in chromosomally conspecific populations in Ecuador of *S. exiguum* (Charalambous, Shelley, Lowry, unpublished data). Head capsule with few, randomly distributed setae on all surfaces. Postgenal cleft as wide as long, rounded anteriorly; postgenal bridge about half as long as hypostomium (Fig. 239). Hypostomium with strongly pigmented anterior margin and nine apical teeth: corner teeth large and blunt, median tooth less developed, but larger than subequal intermediate teeth; 4–5 lateral serrations with hindmost about level with first hypostomial seta; 1+1 groups of four hypostomial setae lying parallel to lateral margins of hypostomium; surface of hypostomium with a few short setae (Fig. 250). Antennae long, unpigmented with segment ratios 23:10:12. Mandible with first three comb teeth decreasing in size posteriorly and two mandibular serrations of which anterior is larger. Maxillary palp about twice as long as breadth at base. Cephalic fan with 30–43 rays (n=10).

Thorax white with grey ring around anterior region and grey pattern dorsally of variable form that almost covers whole area, ventrally with two or three central patches of grey chromatocytes posterior to proleg. Cuticle with occasional small setae dorsally (Fig. 12), glabrous ventrally. Proleg (see Fig. 15) with plates lightly sclerotised with about six processes. Pupal respiratory histoblast dark brown, claviform (Fig. 16).

Abdomen white with single complete black or grey ring on each of four anterior narrow segments; posterior segments grey or black dorsally, white with variable scattered black chromatocytes ventrally. Ventral nerve cord black. Ventral papillae absent. Cuticle with some minute hairs dorsally in dark areas, ventral surface glabrous. Anterior perianal area with group of fine spines. Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with 70–78 rows of 2–14 hooks (n=8). Anal gill trilobed, each lobe with 6–8 long finger-like lobules (Fig. 17).

Taxonomic discussion

The present study showed minor differences between the male ventral and median plates of Brazilian material compared to those of the Caripe onchocerciasis focus in northern Venezuela and several localities in Ecuador as described in Shelley *et al.* (1989). Until chromosomal analyses of these populations are made the taxonomic significance of this variation cannot be assessed.

A full account of the taxonomic problems associated with *Simulium exiguum* and its synonyms has been given in Shelley *et al.* (1989). While this paper was in press Coscarón (1987) further synonymised without explanation *S. urubambanum* Enderlein with *S. exiguum*. This synonymy is supported for the following reasons. Enderlein (1934a) based his description of *S. urubambanum* on a type (=holotype) female from Rosalina on the R. Urubamba in Peru, cited as being deposited in the SMT and on another female (=paratype) from Unini on the R. Ucayali in the ZMHU. We have examined these two specimens, whose depositories were incorrectly cited by Enderlein. Currently the holotype female from Rosalina [12°36'S 72°37'W], labelled as 'typus' is deposited in ZMHU and the paratype female from Unini [10°41'S 73°59'W], also labelled as 'typus' is in the SMT. The abdomen of the pinned holotype specimen, which is in poor condition, has been removed and mounted for examination of the female genitalia. This holotype has been compared with the lectotype and paralectotypes of *S. exiguum* and is morphologically indistinguishable. The paratype of *S. urubambanum* is also in poor condition, has been cleaned in 'Cellosolve' and the head removed and mounted. The scutal pattern and cibarial morphology indicate this specimen as *S. argentiscutum* Shelley & Luna Dias. Of the three synonyms of *S. exiguum*, both *S. glaucophthalmum* and *S. urubambanum* have paraprocts identical to those of *exiguum*; the paraprocts of *S. delpontei* still need to be studied. As discussed in Shelley *et al.* (1989) the value of the form of the female paraproct as an interspecific character still needs to be assessed in *S. exiguum*, its synonyms and the related species *S. llutense*, *S. paraguayense*, *S. subexiguum* and *S. gonzalezi* by using cytologically pure populations. In order to simplify this work three females of the syntype series of females, males and pupae of *S. gonzalezi* from Guatemala and Mexico (Vargas & Díaz Nájera, 1953b) have been examined. It is unclear from the original description of this species as to how many and which specimens from the many localities cited the authors actually examined. The three specimens cited as *S. exiguum* by Knab (1913) collected by Schwarz and Barber at two localities (Livingston and Cacao) in eastern Guatemala and regarded by Vargas & Díaz Nájera as *S. gonzalezi* have been located in the USNM and examined. A slide preparation of the abdomen of one of the two specimens collected 4 miles from Livingston on 20–3–1906 have been made; the paraproct is morphologically identical to that figured by Vargas & Díaz Nájera (1953b) and the specimen has been selected as the lectotype.

Coscarón (1987, 1991) refers to the absence of a spine on the gonostyle in his diagnosis of the subgenus *Notolepria* but figures a socketed spinule and also refers in a previous paper (Coscarón & Wygodzinsky, 1975) to its weak development in this species. Our studies on populations of *S. exiguum* from Brazil, Ecuador and Venezuela and *S. gonzalezi* from Ecua-

dor and Guatemala using both light and scanning electron microscopes showed the presence of a small spine in both species.

The discovery (Procunier *et al.*, 1985) that *S. exiguum* is a complex of at least four cytotaxa in Ecuador emphasises the need for integrated morphological and cytological studies on the widely distributed populations of *S. exiguum* in the Neotropical region, particularly given the importance of this species as a vector of human onchocerciasis.

Distribution

This is principally a lowland forest species in the focus but appeared in low numbers in the highlands at Auaris during the dry/wet season transition (Tables 1,3). In the Venezuelan part of the focus *S. exiguum* has been recorded at lowland Peñascal and Coyowe-teri (Orinoquito) (Table 2). *Simulium exiguum* occurs in the states of Amazonas, Roraima, Mato Grosso, and Goias and the Federal District in Brazil (see Material Examined), a distribution influenced by concerted efforts on simuliid taxonomy in relation to the onchocerciasis foci in Brazil, and the species will no doubt be found at other localities in the future. In a previous study on *S. exiguum* (Shelley *et al.*, 1989a) the distribution of this species was considered for the Neotropical region as a whole and included references to Brazil, some of which now need modification. The distribution records are now more comprehensive (Material Examined) and the reference to 6♀♀ from the R. Ituxi, Amazonas collected by D.Roberts on v.1978 should be deleted. A full distribution of *S. exiguum* is also given by Coscaron (1991).

Simulium (Psaroniocompsa) quadrifidum Lutz

(Colour Plate 1, Fig. 21; Colour Plate 3, Figs 115,116; Figs 38, 49, 60, 71, 82, 93, 104, 136, 149, 160, 171, 182, 194, 215, 227, 240, 251)

Simulium quadrifidum Lutz, 1917: 66. LECTOTYPE pupa, BRAZIL: Rondônia, Madeira-Mamoré region, 1910, (*O. Cruz*) (IOC) [By designation of Shelley *et al.* 1984: 152.] [Synonymised with *S. amazonicum* Goeldi by Cerqueira & Nunes de Mello (1964: 102); revalidated by Shelley *et al.* 1982: 25.] [*Simulium amazonicum* Goeldi sensu Cerqueira & Nunes de Mello, 1964: 106. Male, pupa and larva. Misidentification].

Simulium rassii Ramírez Pérez, 1980: 60. HOLOTYPE ♀, VENEZUELA: Territorio Federal Amazonas, Alto Ventuari, Cacuri, 350m, 1975–80 (collector presumably *J. Ramírez Pérez*) (IND). [Synonymised by Shelley *et al.* 1984: 152.]

Simulium torrealbai Ramírez Pérez, 1980: 64. HOLOTYPE ♀, VENEZUELA: Territorio Federal Amazonas, Departamento de Atabapo, Sierra de Parima, 900m, 1975–80 (collector presumably *J. Ramírez Pérez*) (IND). [Synonymised by Py-Daniel, 1983: 184.]

FEMALE. General body colour black. Body length (alcohol preserved specimens) 1.6–2.7 mm ($\bar{x}$=2.0 mm, s.d.=0.3, n=15); wing length 1.5–2.1 mm ($\bar{x}$=1.8 mm, s.d.=0.2, n=14); wing width .06–1.1 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=14).

Head dichoptic with dark red eyes (appearing black in dried specimens); nudiocular area absent (Fig. 38). Frons and clypeus black with silver pruinosity; frons relatively wide. Occiput black. Mouthparts pale brown. Antennae pale brown with scape and pedicel yellow; first flagellomere often paler than rest; all flagellum covered with short hairs. Cibarium highly sclerotised with deep central trough containing a number of large, rounded, tubercles (Fig. 49).

Scutum velvet black (dark brown in old specimens) with numerous short, stout, brass-coloured setae. Silver pruinose ornamentation consists of pair of submedian divergent bands, widest at anterior scutal border, narrowing in anterior quarter of scutum and coalescing with wide band of silver pruinosity along posterior margin; lateral margins with wide band of silver pruinosity. Humeri dark brown with silver pruinosity. Scutellum velvet brown with long black hairs interspersed with upwardly curving, shorter, paler hairs along posterior margin; lateral borders pruinose. Postnotum black with silver pruinosity. Paranotal folds black with silver pruinosity; scutal margin directly behind paranotal folds with group of recumbent, golden setae (Colour Plate 1, Fig. 21). Pleural region brown with silver pruinosity; antepronotum with pale hairs.

Subcostal wing vein bare and very faint. Radius with 6–10 spine-like setae (occasionally interspersed with finer, hair-like setae) in the distal half (Fig. 60). Basal tuft of dark hairs.

Legs with dark and pale bands (Colour Plate 1, Fig. 21): fore leg with coxa, trochanter, femur and tibia yellow, and tarsi black; mid leg with coxa brown pruinose, trochanter, femur, tibia and all except distal two tarsal segments yellow, second most distal segment mid-brown, distal most segment black; hind leg with coxa brown pruinose, trochanter and basal quarter of femur yellow, basal two-fifths to half of tibia, basal three-quarters of basitarsus and basal half of second tarsus yellow or white, remaining areas and tarsi black. Tarsi narrow as in *S. exiguum* (Fig. 2). Scale-like hairs present on all femora and tibiae as in *S. exiguum* (Fig. 4). Claws long and curved with sharp, sub-basal tooth (Fig. 71). Halteres pale yellow with dark brown stems.

Abdominal tergite I black with fringe of fine, dark hairs; tergite II velvet black with 1+1 large lateral

silver pruinose spots, which occupy most of tergite except tergal plate; tergites III–V velvet black with thin pruinose strip along posterior border; tergites VI–IX shiny black with slight brown mottling (Colour Plate 1, Fig. 21). Tergal plates well developed as in *S. exiguum* (Fig. 5). Sternites dark brown, genitalia brown. Eighth sternite sclerotised with 1+1 groups of 7–14 strong setae and 2–5 weak setae; gonopophyses subtriangular and membranous, lightly sclerotised along inner margins and covered in fine setae (Fig. 82). Cerci approximately hemispherical, paraprocts with flap extending from upper, outer margin (Fig. 93). Genital fork (Fig. 104) with well developed, highly sclerotised, triangular processes; stem long, slender and sclerotised and arms thick with reduced inwardly directed processes. Spermatheca round, highly sclerotised, without discernible internal sculpturing or spicules; width of membranous area of insertion of spermathecal duct small, about quarter maximum width of spermatheca.

MALE. General body colour black. Body length 1.5–2.9 mm ($\bar{x}$=2.2 mm, s.d.=0.3, n=26); wing length 1.4–2.0 mm ($\bar{x}$=1.7 mm, s.d.=0.1, n=24); wing width 0.4–1.0 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=22).

Head holoptic with upper eye facets red, lower eye facets dark red (appearing black in dried specimens). Clypeus, occiput, mouthparts and antennae as in female.

Scutum velvet black with numerous, short, stout brass-coloured setae; with or without, a pair of small, thin, submedian, silver pruinose cunae extending over anterior third. Humeri black (Colour Plate 3, Figs 115, 116). Posterior and lateral margins, scutellum, postnotum and paranotal folds as in female. Pleural region as in female but without mass of setae on scutal margin directly behind paranotal fold.

Wings and legs as in female. Claws curved with large basal tooth. Halteres as in female.

Abdominal tergite I black with basal fringe of many fine hairs; tergite II velvet black with silver pruinosity along anterior margin and in 1+1 large submedian patches; tergites III–VIII velvet black, V–VII with 1+1 submedian spots of silver pruinosity not extending to posterior margin, (largest on tergite V), tergite VIII velvet black; tergite IX black with silver pruinosity (Colour Plate 3, Fig. 115). Sternites and genitalia dark brown, the latter with slight pruinosity. Gonocoxite roughly square, slightly wider than long; gonostyle elongate and roughly triangular being as long as gonocoxite but only half as wide at its maximum width, with large, blunt distal spine (Fig. 136). Ventral plate with sclerotised basal arms and prominent keel; hairs long and numerous, extending over most of plate surface (Fig. 149). Median sclerite slightly longer than wide, with widest point at centre, distal end narrow with slight incision, basal end with corners rounded (Fig. 160). Paramere with three or four prominent spines and many smaller spines of varying size clustered around their bases (Fig. 171).

PUPA. Cocoon length dorsally 1.5–3.2 mm ($\bar{x}$=2.4 mm, s.d.=0.1, n=97), ventrally 1.7–3.4 mm ($\bar{x}$=2.5 mm, s.d.=0.3, n=106); pupa length 1.4–2.6 mm ($\bar{x}$=2.0 mm, s.d.=0.4, n=40); gill length 1.9–5.2 mm ($\bar{x}$=3.2 mm, s.d.=0.7, n=97).

Cocoon slipper-shaped, mid to pale brown; rim of aperture dark brown and reinforced, with short, median protuberance (Fig. 182). Cocoon composed of smooth, finely woven mesh; sides of cocoon flared. Gill light brown with four long, slender filaments arranged in horizontal plane (Fig. 194); main trunk with two primary branches in basal fourteenth; both branches giving rise to two filaments in basal fifth; (these often bifurcate at same level, or inner branch bifurcates slightly distal to outer branch); filaments slender with crenated margins and rounded distally, their surfaces covered with fine spicules. Head (frontoclypeus) with scattered large platelets, some pointed and 2 + 2 well developed and bifid frontal trichomes, and 1 + 1 well developed, bifid, facial trichomes. Thorax with pointed platelets (mainly on anterior half) and 5 + 5 antero-dorsal, well developed bifid trichomes; 1 + 1 simple trichomes on ventral margin beneath gill base, 1 + 1 simple trichomes in central position. Abdominal tergite I with 1 + 1 simple hairs in central area towards lateral margins; tergite II with 3 + 3 simple hairs in row centrally and 2–3 + 2–3 simple hairs laterally; tergites III–IV with 4 + 4 simple hooks towards posterior border of segment and 1 + 1 simple hairs anterior to and between outer two hooks of each group; tergite V with 3–4 + 3–4 simple hairs in row centrally, 1 + 1 simple hairs above outer most hair of each group, and weakly developed submedian row of spines along anterior border becoming a patch of weak spine combs at margins (spines often absent); tergite VI with 2 + 2 simple hairs towards posterior border and poorly developed submedian row of spines along anterior border becoming a patch of weak spine combs at margins; tergite VII as VI except spines and spine combs well developed; VIII with submedian row of prominent spines along anterior border terminating in weak patch of spine combs; IX with 1 + 1 small, rounded apical spines and submedian spines and spine combs toward anterior border. Abdominal sternite III bare; sternite IV with 2–3 + 2–3 simple hairs (sometimes with weak spine combs between outer two); sternite V with 2 + 2 bifid or trifid hooks; sternite VI–VII with 4 evenly spaced hooks, inner pairs bifid or trifid on sternite VI, and bifid on sternite VII, outer pairs simple with poorly developed spine combs above inner two; sternite VIII with 1 + 1 groups of poorly developed spine combs anteriorly.

MATURE LARVA. Body length 3.2–4.5 mm ($\bar{x}$=3.8 mm, s.d.=0.3, n=32); width of head capsule 0.3–0.6 mm ($\bar{x}$=0.5 mm, s.d.<0.1, n=32); length of head capsule 0.4–0.7 mm ($\bar{x}$=0.5 mm, s.d.=0.1, n=32). Body colour dirty white with prominent brown banding in alcohol preserved specimens. Body form as in Fig. 215.

Head pale yellow with brown markings only at base of postgenal cleft and few scattered setae present on all surfaces. Head pattern usually absent or faintly positive (Fig. 227). Postgenal cleft large, as long as wide at maximum width, rounded apex at anterior margin, narrowed at base; postgenal bridge almost as long as hypostomium (Fig. 240). Hypostomium with strongly pigmented anterior margin and nine apical teeth: corner teeth large and pointed, median tooth well developed and larger than subequal intermediate teeth, which are distinct and sharp; 2–6 lateral serrations, the first 2 usually more prominent, hindmost serration level with first hypostomial seta; 1 + 1 group of four hypostomial setae lying parallel to lateral margins of hypostomium, latter one fine (Fig. 251). Antennae long and unpigmented with segment ratios 20:15:30. Mandible with first three (sometimes more) comb teeth long, narrow and of equal size and two mandibular serrations of which anterior is much larger than posterior, which is often reduced to small sharp spine. Simple lateral mandibular process (c/f *S. goeldii* Fig. 260). Maxillary palp short, about three times as long as wide at base. Cephalic fan with 23–39 rays (n=7).

Thorax dirty white with brown ring around anterior region extending along dorsal margin of respiratory gill histoblast; brown patch above and below proleg; coloration generally less prominent dorsally. Cuticle with scattered small setae dorsally. Proleg (see Fig. 15) with very lightly sclerotised plates and 18 processes, arranged in six groups of three. Pupal respiratory histoblast mid brown, claviform.

Abdomen dirty white with single complete brown ring on each of four anterior narrow segments, most prominent on first and faint on remainder; posterior segments mottled white and brown, brown patches on dorsal surface in prominent thick bands, which are most complete on fifth and sixth segments. Ventral papillae very large. Cuticle with numerous small setae on dorsal surface. Anal sclerite with heavily sclerotised arms, but little surrounding sclerotisation; posterior arms extending to rows 10–11 of posterior circlet hooks. Posterior circlet with 55–60 rows of 2–12 hooks (n=3). Anal gill trilobed, each lobe with maximum of seven finger-like lobules.

Taxonomic discussion

Simulium quadrifidum assumed importance when it was confused with *S. amazonicum* (Cerqueira & Nunes de Mello, 1964) during studies on potential simuliid vectors of the filaria *Mansonella ozzardi*. The confusion was resolved by rearing individual pupae of both species to adults from their type localities in the Brazilian Amazon (Shelley *et al.*, 1982). The synonymy of another species, *S. torrealbai*, later described from Venezuela, was made independently by Py-Daniel (1983) and Shelley *et al.* (1984). The latter authors also accepted *S. rassii* (Ramírez Pérez, 1980) as a junior synonym of *S. quadrifidum*, which was followed by Crosskey (1988) and Coscarón (1991). This species shows variation in the female and male scutal patterns and in the pupal gill, but has not been intensively studied because of its zoophilic habits. *Simulium quadrifidum* most closely resembles *S. cauchense*, which can occur sympatrically and from which it may be easily distinguished by female scutal pattern and pupal gill. Py-Daniel (1983) placed both *S. quadrifidum* and *S. cauchense* in a new subgenus *Coscaroniellum*, which Coscarón (1991) maintained. However, Crosskey (1988) suggested that the subgenera *Coscaroniellum, Cerqueirellum* and *Inaequalium* might be merged with *Psaroniocompsa* and Shelley (1988b) included *S. quadrifidum* and *S. cauchense* in the *quadrifidum* group in the subgenus *Psaroniocompsa*, of which *Coscaroniellum* and *Cerqueirellum* were regarded as junior synonyms.

Distribution

This species was found in streams in both lowland (Tootototbi, Mucajai-Igarapé Coroconai) and highland localities (Auaris-Igarapé Hutumati, Serra dos Surucucus-stream near abandoned mission post). It was also collected in low numbers from the R. Tootototbi, where it was the main species present in all seasons, and the R. Auaris in the wet season. In the Venezuela part of the focus it was only collected at Parima B (Table 2) but probably occurs in small streams elsewhere, particularly in lowland forest as in Brazil, since Ramírez Pérez *et al.* (1982) have recorded it in areas adjacent to the focus.

Simulium quadrifidum is one of the more commonly occurring species in the Brazilian Amazon and a widespread Neotropical species. It occurs in Bolivia, Brazil, Ecuador, Guyana, Surinam and Venezuela [Material Examined, Coscarón, 1991; Py-Daniel, 1983; Ramírez Pérez, 1983; Shelley *et al.*, 1982).

Simulium (Psaroniocompsa) cauchense Floch & Abonnenc

(Colour Plate 1, Fig. 22; Fig. 195)

Simulium cauchense Floch & Abonnenc, 1946c: 1. LECTOTYPE ♂, FRENCH GUIANA: Crique Patawa, Bassin de Caux, iii–iv.1946 (*H. Floch & E. Abonnenc ?*) (IP) [designated by Shelley *et al.*, 1984: 144.]

Simulium rangeli Ramírez Pérez, Rassi & Ramírez, 1977: 163. HOLOTYPE ♀, VENEZUELA: Territorio Federal Amazonas, Departmento de Atabapo, Sierra da Parima, Rio Niayopeu (no collection date) (*J. Ramírez Pérez*) (in first author's personal collection). [Synonymy in World Health Organization, 1982: 3.]

Simulium sextobecium Nunes de Mello, 1974: 15. HOLOTYPE ♀, BRAZIL: Roraima Territory, Acampamento da Boca da Mata, Br 174, Igarapé Cunaen, xii.1972 (*J.A. Nunes de Mello & E. Vieira da Silva*) (INPA-Holotype lost, pers. comm. V. Py-Daniel, 1982). [Synonymy in World Health Organization, 1982: 3.]

FEMALE. General body colour black. Body length 1.4–2.3 mm ($\bar{x}$=1.7 mm, s.d.=0.3, n=6); wing length 1.3–1.7 mm ($\bar{x}$=1.5 mm, s.d.=0.1, n=6), wing width 0.6–1.0 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=4).

Coloration and morphology as in *S. quadrifidum* except as follows.

Scutum velvet black with pair of silver pruinose, submedian, comma-shaped marks situated in anterior half of scutum visible with posterior illumination. Comma-shaped marks visible only along edges with anterior illumination (Colour Plate 1, Fig. 22).

Radius of wing with 5–8 spine-like setae in the distal two-fifths and occasional finer, hair-like seta.

MALE. General body colour black. Body length (alcohol preserved specimens) 1.4–2.4 mm ($\bar{x}$=1.9 mm, s.d.=0.2, n=11); wing length 1.1–2.0 mm ($\bar{x}$=1.6 mm, s.d.=0.3, n=9); wing width 0.4–1.1 mm ($\bar{x}$=0.8 mm, s.d.=0.2, n=8).

Coloration and morphology of male as *S. quadrifidum* except as follows. Tergite VIII shiny in central region of tergal plate. Paramere with several spines of varying size in distal third.

PUPA. Cocoon length dorsally 1.4–2.4 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=23); ventrally 1.5–2.6 mm ($\bar{x}$=2.1 mm, s.d.=0.3, n=22); pupa length 1.6–2.5 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=16); gill length 2.7–3.6 mm ($\bar{x}$=3.1 mm, s.d.=0.3, n=9).

Coloration and morphology as in *S. quadrifidum* except as follows.

Gill light brown with four long, slender filaments arranged in vertical plane (Fig. 195); main trunk with two primary branches in basal tenth, both of which bifurcate in basal half of gill. Dorsal bifurcation further along gill than ventral bifurcation (dorsal bifurcation often near to mid point of gill). Tergite V without spines or spine combs on anterior border.

MATURE LARVA. Body length 2.8–3.7 mm ($\bar{x}$=3.2 mm, s.d.=0.23, n=24); width of head capsule 0.4–0.5 mm ($\bar{x}$=0.4 mm, s.d.=0.03, n=24); length of head capsule 0.4–0.6 mm ($\bar{x}$=0.5 mm, s.d.=0.05, n=24).

Colour and morphology as in *S. quadrifidum*. The following data are regarded as within the variation seen for *S. quadrifidum* and are not interspecific characters: antennal ratio 10:5:16, cephalic fan with 37–42 rays (n=12), proleg plate with 6–14 processes, anal sclerite with posterior arms extending to rows 10–12 of posterior circlet hooks, posterior circlet with 62–73 rows of 2–14 hooks (n=8), anal gill tri-lobed with 3–7 lobules (n=9).

Taxonomic discussion

The taxonomy of this species has been straightforward. Since its description from French Guiana (Floch & Abonnenc, 1946c) it has been found in Brazil, where it was described as *S. sextobecium* (Nunes de Mello, 1974) and in Venezuela, where it was given the name *S. rangeli* (Ramírez Pérez *et al.*, 1977). Synonyms proposed by Shelley and co-workers (including *sextobecium* and *rangeli* as junior synonyms of *cauchense*, were agreed at an informal workshop on the taxonomy of South American Simuliidae in 1982, a report on which was subsequently published (World Health Organization, 1982). *Simulium sextobecium* and *rangeli* were then cited as new junior synonyms of *S. cauchense* in subsequent publications (Py-Daniel, 1983; Shelley *et al.*, 1984). The subgeneric placement of this species was discussed under *S. quadrifidum*.

Distribution

This species was less common than *S. quadrifidum*, being recorded from Auaris (Igarapé Hutumati), Serra dos Surucucus (small stream at Dalem) and Mucajai (Igarapé Coroconai) (Table 1). In the Venezuela part of the focus it was found only at Parima B (Table 2).

Outside the focus in Brazil it has a restricted distribution in forest in Roraima and Amapá States (Material Examined) and has been recorded in northern Amazonas (Py-Daniel, 1983). It also occurs in French Guiana, Guyana and Venezuela (Material Examined; Floch & Abonnenc, 1946c; Py-Daniel, 1983; Ramírez Pérez *et al.*, 1982 [as *rangeli*]).

Simulium oyapockense/roraimense

The morphological similarity and overlap in character variations for these two species makes it appropriate to deal with them together. Difficulty of access to breeding grounds in the onchocerciasis focus meant that immature stages and males, which have the characters necessary for species separation, were not obtained for most localities. Species identification beyond *oyapockense/roraimense* has therefore been impossible at localities where only man-biting females have been collected. The following description of *S. oyapockense* is based on large numbers of specimens collected from Cachoeira Bem Querer on the R. Branco,

south of Boa Vista and to the east of the onchocerciasis focus in Roraima State. Morphological differences from *S. oyapockense* (Bem Querer) are then recorded under the brief description of *S. roraimense* from its type locality at Cachoeira, R. Cauamé, a tributary of the R. Branco close to Boa Vista. The considerable variation in *S. oyapockense* (Bem Querer) and *S. roraimense* (Cauamé) is then discussed in relation to other collection localities in Brazil, both within and outside the focus. Variation of major characters in *S. oyapockense* and *S. roraimense* from localities on rivers in the onchocerciasis focus (all tributaries of the Rio Branco) and from the limited material available from the type locality of *S. oyapockense* (R. Oyapock on the Brazil/French Guiana border) all falls within the range seen for these two species at Bem Querer and Cauamé.

Simulium (Psaroniocompsa) oyapockense Floch and Abonnenc

(Colour Plate 1, Figs 23,24,25; Colour Plate 3, Figs 117,118,119; Figs 39, 50, 61, 72, 83, 94, 105, 137, 150, 161, 172, 183, 196, 211, 216, 228, 241, 252)

Simulium oyapockense Floch & Abonnenc, 1946c: 4. LECTOTYPE ♀, FRENCH GUIANA: Maripa, R. Oyapock, near Cafésoca Falls (no collection date, collector probably E.Abonnenc) (IP) [By designation of Shelley *et al.*, 1984: 147].

Simulium pseudosanguineum Ramírez Pérez & Peterson, 1981a: 154. HOLOTYPE ♀, VENEZUELA: Bolívar State, Piar District, Canaima (no collection date or collector) (IND). [Synonymy by Ramírez Pérez, 1983: 8.]

Simulium sanchezi Ramírez Pérez, Yarzábal & Peterson, 1982: 71. HOLOTYPE ♀, VENEZUELA: Amazonas State, Departamento Rio Negro, San Carlos de Rio Negro, Raudal Mabajate, 100m (no collection date or collector) (IND). [Synonymy by Shelley *et al.*, 1984: 147.]

Simulium cuasisanguineum Ramírez Pérez, Yarzábal & Peterson, 1982: 36. HOLOTYPE ♀, VENEZUELA: Tamatama, junction between Orinoco river and the Casiquiare canal, 150m, 2°01'N 67°07'W (no collection date or collector) (IND). [Synonymy by Shelley *et al.*, 1987a: 462.]

Simulium pseudoamazonicum Ramírez Pérez & Peterson, 1981a: 151. HOLOTYPE ♀, VENEZUELA: Aragua State, Urdaneta District, Barbacoas (no collection date or collector) (IND). **New synonymy**

The major misidentifications of this species are listed in table 4.

FEMALE. General body colour black with silver pruinosity. Body length 1.4–2.6 mm ($\bar{x}$=2.1 mm, s.d.=0.3, n=43); wing length 1.2–1.9 mm ($\bar{x}$=1.5 mm, s.d.=0.1, n=42), wing width 0.5–1.0 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=32).

Head dichoptic with dark red eyes (appearing black in dried specimens); nudiocular area minute or absent (Fig. 39). Frons, clypeus and occiput black with faint silver pruinosity. Mouthparts brown with maxillary palps dark brown. Antennae dark brown with scape, pedicel and basal third of first flagellomere yellow/orange. Cibarium with 1+1 groups of large, pointed teeth (21–28) either side of deep, narrow, sclerotised central trough and extending on to heavily sclerotised cornua (Fig. 50).

Scutum black with silver pruinosity and numerous recumbent slender gold hairs. Scutal pattern highly variable in relation to illumination. With anterior lighting black areas of scutum on silver pruinose background as follows: wide median black vitta extending from anterior border for about three quarters of scutum, rounded and twice as wide posteriorly as on anterior scutal border; pair of disc-shaped areas between median vitta and lateral margin of scutum, beginning in second quarter of scutum and extending to same posterior limit as median vitta; pair of comma-shaped marks extending from anterior scutal border to mid point of scutum in silver pruinose area between median vitta and disc-shaped areas (Colour Plate 1, Fig. 23). With posterior lighting median black vitta remains the same while the pair of disc-shaped areas extend to anterior margin of scutum to form bands running nearly parallel to median vitta; pair of comma-shaped marks appear narrower and bright silvery-white pruinose (Colour Plate 1, Fig. 24). Humeri silver pruinose regardless of light direction. Scutellum velvet brown with long dark and short, recumbent, golden setae at posterior margin. Postnotum silver pruinose; paranotal folds with silver pruinosity. Pleural region uniformly dark brown with light pruinosity.

Subcostal wing vein bare. Radius with 4–9 spines in distal half (Fig. 61). Costal base tuft of dark hairs.

Legs with dark and pale bands (Colour Plate 1, Fig. 23). Fore leg with coxa mid brown, often slightly darker on upper inner edge; trochanter, femur and tibia yellow to pale brown; tarsi dark brown. Mid leg with coxa dark brown; trochanter, femur and tibia pale to mid-brown (femur and tibia often mid brown in central half/three-quarters); distal two tarsomeres brown; remaining tarsi yellow, occasionally darker at posterior margin. Hind leg with coxa dark brown; trochanter pale brown; femur becoming progressively darker distally with a maximum of basal sixth pale brown and minimum of distal quarter dark brown; distal half of tibia, distal fifth/quarter of basitarsus dark brown, distal third of second tarsomere mid brown, third tarsomere often as second or completely mid brown as remaining tarsi; remaining areas white. Fore tarsi narrow as in *S. exiguum* (Fig. 2). All femora and tibiae with scales as in *S. exiguum* (Fig. 4). Claws slender,

slightly curved and lacking basal tooth (Fig. 72). Halteres pale white/yellow with only basal area of stem dark.

Abdominal tergites all dark brown (Colour Plate 1, Fig. 23); tergite I velvety with basal fringe of few, brown, medium-length hairs; tergite II with silver pruinosity; tergites III–V velvety with both anterior and posterior margins pruinose; tergites VI–IX shiny. Tergal plates well developed as in *S. exiguum* (Fig. 5). Sternites and genitalia pale brown. Eighth sternite usually lightly sclerotised with 10–17 (4–7 weak, 6–10 strong) setae on each side (Fig. 83); gonopophyses small, membranous with light sclerotisation on inner margin and numerous minute setae. Cerci hemispherical; paraprocts small and rounded (Fig. 94). Genital fork (Fig. 105) with heavily sclerotised spatulate stem, anterior processes poorly developed; arms broad. Spermatheca oval, sclerotised, with faint surface sculpture and transverse rows of spicules occurring in groups; area of insertion of spermathecal duct membranous and about one third as wide as maximum width of spermatheca.

MALE. General body colour black with silver pruinosity. Body length 1.7–2.4 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=15); wing length 1.2–1.6 mm ($\bar{x}$=1.4 mm, s.d.=0.1, n=13); wing width 0.4–1.0 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=9).

Head holoptic with upper eye facets red/brown and lower eye facets dark red (appearing black in dried specimens). Rest of head coloration as in female.

Scutum velvet-black with pair of submedian silver cunae extending for 1/2 to 2/3 length of scutum from anterior scutal border (Colour Plate 3, Fig. 117) (only visible with light source anterior to specimen). Posterior and lateral borders with wide band of silver pruinosity. Scutum with recumbent golden hairs. Humeri black. Coloration of rest of thorax as in female.

Wing setation as in female.

Leg and halter coloration as in female (Colour Plate 3, Fig. 117).

Abdominal tergites dark, velvet brown with scattered golden setae (Colour Plate 3, Fig. 117); basal fringe of long and short, fine, dark hairs. Tergite II silver pruinose except for small central area of tergal plate; tergite VI with large, submedian, silver pruinose spots which are separated only in centre by narrow dark sclerotised plate; tergites VII–VIII with progressively smaller submedian silver pruinose spots; tergite IX silver pruinose. Tergal plates well developed as in *S. exiguum* (Fig. 5) and dark brown. Sternites dark brown; genitalia dark brown with light silver pruinosity. Gonocoxite almost rectangular, slightly wider than long; gonostyle stout and subrectangular, about two-thirds length of gonocoxite; subterminal spine large, stout and club-shaped (Fig. 137). Ventral plate with short, thick basal arms; keel prominent; coarse hairs covering most of ventral plate except arms, longer on keel than elsewhere (Fig. 150). Median sclerite with small lateral processes as in Fig. 161. Paramere with several, large, well developed spines occurring in two groups interspersed with smaller spines (Fig. 172).

PUPA. Cocoon length dorsally 1.6–2.3 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=10); ventrally 1.7–2.4 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=10); pupa length 1.5–2.1 mm ($\bar{x}$=1.9 mm, s.d.=0.2, n=10); gill length (longest intact filaments) 0.8–1.5 mm ($\bar{x}$=1.0 mm, s.d.=0.2, n=10). Topotypes from R. Oyapock: cocoon length dorsally 1.6–2.8 mm ($\bar{x}$=2.1 mm, s.d.=0.3, n=25); ventrally 1.5–2.6 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=26); pupa length 1.7–1.8 mm (n=2); gill length 0.7–1.5 mm ($\bar{x}$=1.0 mm, s.d.=0.2, n=20).

Cocoon slipper–shaped, mid to dark brown; rim dark, thickened, with slight median protuberance (Fig. 183). Cocoon of closely woven threads, sides not flared. Gill light brown with six forwardly directed tubular filaments orientated in vertical plane (Fig. 196). Gill basal trunk immediately divides to form three primary branches, dorsal, median and ventral, each then bifurcating to form six filaments. Typical gill configuration with dorsal bifurcation most basal and median and ventral at about same height from base. Dorsal primary branch bifurcating nearest base in basal 1/6 to 1/10 of gill; median primary branch in basal 1/5 to 1/7 and ventral primary branch in basal 1/3 to 1/5 (in topotypes from the R. Oyapock dorsal of three main branches bifurcates in basal 1/7; median branch in basal 1/7 to 1/5 and basal branch in basal 1/3 to 1/5.) Gill filaments rounded distally, margins crenated and with spicules. Spicules in trunk region larger and grouped together in short longitudinal rows. Head (frontoclypeus) with 2 + 2 short, simple, frontal and 1 + 1 simple or bifid facial trichomes; frontal area covered in numerous, large, round platelets; remaining areas of frontoclypeus with smaller platelets. Thorax with 5 + 5 simple, bifid or rarely with one trifid antero-dorsal trichomes (most dorsal smaller than others); 1 + 1 simple trichomes directly beneath spiracular trunk; 2 + 2 simple, fine trichomes at ventral margin below gill base; 1 + 1 small, simple trichomes in central region of thorax. Numerous, rounded platelets over entire surface, particularly obvious in anterior half (Fig. 211). Abdominal tergite I with 1 + 1 simple, submedian hairs towards anterior margin; tergite II with 4 + 4 simple hairs in row centrally with 1 + 1 simple hairs anterior to outer two hairs of each row, and 1 + 1 patches of spine combs towards antero-lateral margin in most specimens; tergite III with 4 + 4 simple hooks on posterior border of segment, 1 + 1 simple hairs anterior to outer two hooks of each group and 1 + 1 patches of spine combs towards antero-lateral border; tergite IV with 4 + 4 simple hooks towards posterior border and 1 + 1 simple hairs anterior to outer two of

each group; tergite V with 4 + 4 fine hairs centrally; tergite VI with 2 + 2 fine hairs centrally and 1 + 1 areas of poorly developed spine combs at antero-lateral border; tergite VII with 1 + 1 rows of spines on anterior margin of segment, 1 + 1 areas of poorly developed spine combs on antero-lateral border and 1 + 1 fine, sub median hairs centrally; tergite VIII with row of well developed spines across anterior region of segment and 1+1 areas of spine combs at lateral margin and 1 + 1 fine hairs centrally; tergite IX with 1 + 1 small rounded apical spines, 1 + 1 groups of anterior spines becoming spine combs at lateral margins. Sternite III with 1 + 1 areas of spine combs towards anterior margin; sternite IV with 1 + 1 bifid or trifid hooks and 1+1 groups of spine combs antero-laterally; sternite V with 2 + 2 hooks, the inner pair 3–4 pronged and outer pair trifid or bifid, and 1+1 areas of spine combs anterior to outer two hooks; sternites VI–VII with 4 evenly spaced hooks, inner pair trifid or bifid, outer pair bifid or simple, and with spine combs anterior to outer two hooks; sternite VIII with continuous band of spine combs on anterior margin.

MATURE LARVA. (Described mainly from material preserved in Carnoy's fluid in which body colour is accentuated.) Bem Querer-body length 3.2–3.9 mm ($\bar{x}$=3.4 mm, s.d.=0.13, n=19); width of head capsule 0.4 mm ($\bar{x}$=0.4 mm, s.d.=0.02, n=19); length of head capsule 0.4–0.5 mm ($\bar{x}$=0.5 mm, s.d.=0.03, n=19). Topotype larvae from Oyapock show similar variations except that coloration is sometimes reddish brown. R. Oyapock: body length–2.8–3.6 mm ($\bar{x}$=3.1 mm, s.d.=0.23, n=16), head length 0.4 mm ($\bar{x}$=0.4 mm, s.d.= 0.03, n=15), head width 0.3–0.4 mm ($\bar{x}$=0.4 mm, s.d.=0.03, n=7). Body form as in Fig. 216.

Head yellow with few, minute mainly dorsal setae [some specimens from R. Oyapock had very dense setae]. Head spots generally indistinct or with faint positive pattern (Fig. 228). Postgenal cleft large, approximately as long as wide at widest point, narrow at base and with pointed apex; postgenal bridge about half as long as hypostomium (Fig. 241). Hypostomium with strongly pigmented, anterior margin and nine apical teeth; corner teeth double cusped, median tooth large, remaining teeth subequal and pointed; 4–7 lateral serrations, upper two more pronounced [topotypes 4–7); 1 + 1 groups of three hypostomial setae parallel to lateral margins of hypostomium; surface of hypostomium with several short setae towards lower margin (Fig. 252). Antennae long, unpigmented with segment ratios 7:6:9 [topotypes 10:9:11]. Mandible with second and third comb teeth of equal size, but smaller than first. One mandibular serration generally present, but if two posterior smaller. Maxillary palp about twice as long as breadth at base. Cephalic fan with 19–25 rays (n=9); topotypes from R. Oyapock with 20–43 rays (n=18).

Thorax pale with small, amorphous, grey patches around histoblast and posterior to proleg. Variations in which the pattern is very faint or dark green or grey also commonly occur. Cuticle with numerous small setae dorsally, fewer ventrally. Proleg (see Fig. 15) poorly sclerotised with 14–18 processes (R. Oyapock specimens with 12–16). Pupal respiratory histoblast pale brown and claviform.

In one of commonest forms, abdomen white with single prominent grey band on first narrow abdominal segment and with less prominent bands on segments two, three and four and with grey patches on dorsal and ventral surfaces of swollen area of abdomen, often obvious as four transverse rings on dorsal surface and anterior to anal sclerite. At Bem Querer two less common extremes occur where above banding pattern is dark grey or dark green and banding on narrow abdominal segments prominent, and where banding pattern except for first abdominal grey ring is faint and almost absent. Ventral papillae present but reduced. Cuticle with many setae on dorsal surface, coarser posteriorly, ventral surface with few setae. Anal sclerite lightly sclerotised with posterior arms extending to row 8–9 of posterior circlet hooks. Posterior circlet with 58–60 rows of 12 hooks (n=3) (topotype with 55 rows). Anal gill trilobed, with 6–9 lobules (n=6).

Distribution

The taxonomic proximity of *S. oyapockense* to *S. roraimense* and lack of characters to distinguish females preclude provision of a precise distribution for each species. They can only be separated reliably in the male and immature stages at Cachoeira Bem Querer, Oyapock and Cauamé and several other locations recorded in Material Examined. Distributions are thus only accurate where reared material has been available for study. Limited data from larval polytene chromosomes and female cuticular hydrocarbons have been also used when available. In most localities in the focus, where only man-biting females have been collected, identifications are indicated as *S. oyapockense/ roraimense*. Only a single male was reared from a pupa at Toototobi and this was nearer *S. oyapockense* than *S. roraimense*. Several reared females at Mucajai were probably *S. oyapockense* based on pupal characters, only *S. roraimense* was found at Catrimani and cuticular hydrocarbon profiles showed both *S. oyapockense* and *S. roraimense* to be present at Parimiu (Material Examined).

Although occurring in both lowland and highland localities of the Amazonia focus this species was most predominant in the lowland forest areas (Tables 1 & 2). It has a very wide distribution outside the focus, in the Amazon and Orinoco basins particularly. In Brazil it is found in the states of Pará, Roraima, Rondonia, Amapá,

and Amazonas and also occurs in Bolivia, Colombia, Ecuador, French Guiana, Guyana and Peru.

Simulium (Psaroniocompsa) roraimense Nunes de Mello

(Colour Plate 3, Fig. 120; Figs 138,197,212)

Simulium roraimense Nunes de Mello, 1974: 45. HOLOTYPE ♂, BRAZIL: Roraima Territory, Cachoeira, Rio Cauamé (as Cauomé), 3km above bridge on BR 174, xi.1972 (J. A. Nunes de Mello) (INPA).

FEMALE. General body colour black with silver pruinosity. Body length 1.5–2.8 mm ($\bar{x}$=2.1 mm, s.d.=0.3, n=38); wing length 1.1–1.8 mm ($\bar{x}$=1.5 mm, s.d.=0.1, n=38), wing width 0.5–0.8 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=32).

Coloration and morphology as in female *S. oyapockense* (Bem Querer).

MALE. General body colour black with silver pruinosity. Body length 1.6–3.0 mm ($\bar{x}$=2.5 mm, s.d.=0.3, n=19); wing length 1.2–1.7 mm ($\bar{x}$=1.5 mm, s.d.=0.1, n=19); wing width 0.6–0.8 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=11).

Coloration and morphology as in male *S. oyapockense* (Bem Querer) except as follows. Silver cunae of scutum more slender and extending posteriorly to join silver posterior scutal border; with anterior lighting pair of black, comma-shaped marks in anterior third of thorax within cunae; with posterior lighting these marks become silver (Colour Plate 3, Fig. 120).

Submedian silver pruinose ornamentation on tergites VI–VIII of abdomen less reduced (Colour Plate 3, Fig. 120). Gonostyle subtriangular, slightly curved, about three-quarters length of gonocoxite; subterminal spine large (Fig. 138). [This character requires further investigation for its potential in separating *S. roraimense* from *S. oyapockense*].

PUPA. Cocoon length dorsally 1.9–2.4 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=9); ventrally 2.2–2.8 mm ($\bar{x}$=2.5 mm, s.d.=0.2, n=9); pupa length 1.8–2.4 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=10); gill length (longest intact filaments) 1.9–2.6 mm ($\bar{x}$=2.2 mm, s.d.=0.2, n=8).

Cocoon and pupa as in *S. oyapockense* (Bem Querer) except as follows. The pupal gill (Fig. 197) is generally longer than in *S. oyapockense* with primary branch heights more distal: dorsal primary branch bifurcation in basal 1/6–1/14, median in basal 1/5–1/9, ventral in basal 1/5–1/9. Filaments generally more slender. Abdominal tergites II–III without patches of spine combs. Platelets on thorax mainly pointed on dorsum (Fig. 212).

MATURE LARVA. Body length 3.8–4.5 mm ($\bar{x}$=4.1 mm, s.d.=0.3, n=5); width of head capsule 0.4–0.6 mm ($\bar{x}$=0.5 mm, s.d.<0.1, n=5); length of head capsule 0.5–0.8 mm ($\bar{x}$=0.6 mm, s.d.=0.1, n=5).

Larvae as *S. oyapockense* except body colour in two main forms: dark green and dark brown. Pale forms with prominent first abdominal band less common. Head capsule with many dorsal setae. Hypostomium with 3–7 lateral serrations; cephalic fan with 30–37 rays (n=16). Head spots as in *S. oyapockense*, but sometimes very dark.

Proleg plates lightly sclerotised and with 12–18 processes. Anal sclerite well sclerotised. Anal gill trilobed, each with 7–10 club-like lobules.

Variation

The typical forms of *S. oyapockense* and *S. roraimense* on which the above descriptions have been based are found at Cachoeira Bem Querer and Cachoeira, Rio Cauamé (type locality) in Roraima State respectively. Considerable variation has been noted for each species within these two localities and at other localities in all life stages used for identification. Those variations that cause identification difficulties are discussed below.

Variation in female scutal pattern is minimal, minor differences being observed in the dimensions of the vittae and comma-shaped intervittal marks in *S. oyapockense* and *S. roraimense* from some localities. The major problem is that this character does not function for distinguishing *S. roraimense* from *S. oyapockense*, which often occur sympatrically, nor from *S. sanguineum* that occurs in Colombia and Panama to the west of the Andes. Coscarón (1991) used variation in these intervittal marks to distinguish *S. oyapockense* from *S. pseudoamazonicum* and *S. cuasisanguineum*, which we consider conspecific, but did not consider *S. roraimense*. Although *S. oyapockense* and *S. amazonicum* can be easily distinguished at most localities by the presence of a comma-shaped intervittal mark or a diffuse mark respectively, this character can be intermediate at some localities. Thus, on the R. Ituxi in Amazonas where *S. amazonicum* and *S. oyapockense* [identified from reared males] females are sympatric, specimens occur that are indistinguishable on scutal pattern (Colour Plate 1, Figs 25, 26), but separable on the 8 filamented (*amazonicum*) or 6 filamented (*oyapockense*) gill if reared females are available. Similar man-biting females, currently unidentifiable, occur on the Northern Perimeter Road in Roraima. The significance in variation in the number of cibarial teeth needs investigation since specimens from the R. Oyapock had only 15–18 in each group compared to 21–28 at Bem Querer. It is often difficult to count all the teeth in specimens because the cibarium needs to be viewed at high power from several angles requiring dissection and mounting of an extremely small structure.

In the male one major character, the size of the

scutal cunae, varies considerably. The typical Bem Querer form, where the cunae occur in the proximal 1/2 to 2/3 of the scutum, is also seen in the population (described as *S. cuasisanguineum*) from San Carlos, Rio Negro, Venezuela. In other localities (R. Arraia and R. Takutu, Roraima) in Brazil and the population at Siquita, TFA, Venezuela (described as *S. sanchezi*) the scutal cunae extend for about 3/4 of the scutal length and sometimes end with fine tails distally (Colour Plate 3, Fig. 118). In two Brazilian localities (R. Maú, Roraima and in the onchocerciasis focus at the R. Toototobi) the silver cunae extend to almost join the silver pruinose posterior border of the scutum as occurs in *S. roraimense*, but there are no comma-shaped marks (Colour Plate 3, Fig. 119). Similar variation is seen in *S. sanguineum* (also in the *S. amazonicum* group) from Colombia (Tidwell *et al.*, 1981b). Coscarón (1991) used the dimensions of these cunae to distinguish *S. oyapockense* from *S. cuasisanguineum* and *S. pseudoamazonicum*, which are regarded as conspecific here. The present study indicates that the presence or absence of comma-shaped marks in the cunae and the form of the gonostyles are the only characters that can be used reliably to distinguish male *S. oyapockense* from *S. roraimense* in most localities.

The most common variation in pupae of both *S. oyapockense* and *S. roraimense* occurs in gill branching, where the ventral bifurcation of the gill is significantly more distal to the median. In *S. roraimense* the median bifurcation is occasionally the most distal. Gill branching may sometimes differ on each side of the specimen. Gill length is a character that potentially could be used to distinguish *S. oyapockense* from *S. roraimense*, but several practical problems exist. Individual filament lengths in each specimen may vary significantly; a typical sample of shortest to longest gill filaments in *S. oyapockense* at Bem Querer was 0.7–1.5 mm (n=13) and in *S. roraimense* at Cauamé 1.4–2.5 mm (n=9) with the greatest difference in filament length in one specimen being 0.4 mm for *S. oyapockense* and 0.6 mm for *S. roraimense*. Very few specimens had all filaments intact and so exact measurements could not be made on all filaments. Additionally, the longest and shortest filaments on one specimen did not always correspond to the equivalent filaments on another. Generally, any of the filaments can be the shortest or the longest in *S. oyapockense*, while in *S. roraimense* the shortest filament in the present material is always the most dorsal filament of the dorsal bifurcation and the longest is found on either the median or ventral bifurcations. Measurements can thus only be used for an approximation of gill length in most cases. Py-Daniel (1983) used the length of the longest filaments to separate the two species (*S. oyapockense* 0.77–0.8 mm; *roraimense* 1.7–1.8 mm) but the ranges found in the present work (*S. oyapockense* 0.8–1.5 mm; *S. roraimense* 1.9–2.6 mm) indicate the large variation in this character seen in a small sample and the difficulty in determining the longest filament. The density of platelets in the pupal cephalothorax is another character whose variation requires further study. This character varies in different populations of *S. roraimense* and *S. oyapockense* in Brazil, and in *S. cuasisanguineum* (synonym of *S. oyapockense*) platelets are very sparsely distributed. Coscarón (1991) uses this as the principal character for separating *S. cuasisanguineum* from *S. oyapockense, S. pseudoamazonicum* and *S. roraimense*. Another character that varies is the form (pointed or rounded) of platelets on the pupal cephalothorax. In populations of *S. oyapockense* (Bem Querer, Oyapock) platelets were all rounded whereas in *S. roraimense* (Cauamé, Catrimani) most were pointed. However, this character does not function for all populations of these two species and therefore cannot be used without male scutal pattern for distinguishing *S. oyapockense* from *S. roraimense* and determining their distributions. Thus, at the rivers Jacy Parana, Ituxi, Toototobi and Arraia (see Material Examined) male scutal patterns indicate the presence of *S. oyapockense* but platelets on the cephalothorax of link reared specimens are of the *S. roraimense* type.

Variation also occurs in the coloration of larvae of *S. roraimense* at its type locality and of *S. oyapockense* from Bem Querer and Oyapock. However, more intensive sampling is necessary. The number of anal gill lobules is a character used for distinguishing these two species by Py-Daniel (1983) but this character did not function for the populations of this species examined in the current work.

The considerable overlap in morphological variation, particularly in *S. oyapockense* and *S. roraimense*, highlighted in the present study and to a lesser extent with *S. sanguineum* and *S. amazonicum* clearly indicates that morphological characters alone are not completely adequate for defining species limits in the *amazonicum* group. Preliminary data on larval polytene chromosomes (Procunier et al., 1987) showed that *S. oyapockense* (Bem Querer) is distinct chromosomally from *S. roraimense* (Cauamé) and that both may be distinguished by this method from a population in Ecuador referred to as *S. oyapockense* manabi form in Procunier (1989) and Procunier *et al.* (1987). Clear differences in cuticular hydrocarbon profiles of female flies have been found in *S. oyapockense* Bem Querer and *S. roraimense* Cauamé and this method has been used to determine unidentified man-biting females at Parimiu in the onchocerciasis focus as *S. oyapockense* (A.Phillips and D.Molyneux, personal communication). Integrated taxonomic studies are now needed to interpret the variations described above. These would use polytene chromosome banding sequences to initially define the cytotaxa present and then variations seen in morphology, enzymes, hydro-

carbons and DNA could be directly related to cytotaxon. Accurate identification of female flies (probably using enzymes or DNA) to cytotaxon would be needed to enable the biology and vector role in onchocerciasis of *S. oyapockense* and *S. roraimense* to be carried out. A precedent for this type of work exists with the *S. damnosum* vector species complex in West Africa. Here, male scutal patterns, which were supposedly diagnostic for separating six of the cytospecies of *S. damnosum* (Dang & Peterson, 1980) have subsequently been found to exhibit considerable intraspecific variation when integrated morphological and cytological studies were made on adults reared from single egg batches of two of the cytospecies (Meredith et al., 1983). Although no similar studies have yet begun in Latin America, preliminary work has shown the presence of isoenzyme variation in simuliid vectors in Central America and Ecuador (Agatsuma *et al.*, 1986, 1987; Charalambous *et al.*, 1993; Petersen, 1982).

Taxonomic discussion

Considerable confusion has surrounded various species of the *Simulium amazonicum* group, of which *S. oyapockense* and *S. roraimense* are two members, since Goeldi first described *S. amazonicum* from the Brazilian Amazon in 1905. Several species in the group are anthropophilic and some are vectors of filariae that parasitise man and for these reasons this species group is probably the most studied in the Neotropical fauna. Key papers for data on the history of the group's taxonomy are Shelley (1988b) and Shelley *et al.* (1987a). Authors are now in agreement on the identities of *S. amazonicum, S. argentiscutum, S. oyapockense* and *S. sanguineum* of the *amazonicum* group and *S. minusculum* of the subgenus *Psaroniocompsa*. Agreement has not yet been reached on the specific status of certain other members of the group accepted as synonyms of *S. oyapockense* by Shelley (1988b) and cytological data are needed to evaluate minor morphological variations on which they were based. Thus, Coscarón (1991) maintains *S. cuasisanguineum* and *S. pseudoamazonicum* as valid species while Py-Daniel (1983) additionally maintains *S. pseudosanguineum* and *S. sanchezi* as valid. The synonymy of *S. pseudosanguineum* with *S. oyapockense* presented by Shelley and co-workers in an informal workshop on taxonomy of SouthAmerican Simuliidae was not accepted by all other workers present. The subsequent publication of this synonymy by Shelley *et al.* (1984) was pre-empted by Ramírez Pérez (1983). Subgeneric placement of species has also not yet been agreed. Py-Daniel and Coscarón prefer to combine the *amazonicum* group with two closely related species in a subgenus *Cerqueirellum* while Shelley and co-workers maintain the group in the subgenus *Psaroniocompsa* (Coscarón, 1991; Py-Daniel, 1983; Shelley, 1988b; Taxonomic discussion under *S. quadrifidum*).

The above section on intraspecific variation clearly shows that scutal patterns in both sexes of adults have to be used judiciously with other data when making identifications, because of increasing interspecific overlap found as larger numbers of specimens are examined. The finding of man-biting females that are difficult to distinguish from *S. oyapockense* and *S. amazonicum* in an area (Northern Perimeter Road) where only pupae with 6-filamented gills are found has prompted the above new synonymy of *S. pseudoamazonicum* with *S. oyapockense*. This, together with the occurrence of *S. amazonicum* and *S. oyapockense* females sympatrically (R. Ituxi) that could not be assigned to either species except on gill filament number (*amazonicum* 8, *oyapockense* 6) because of scutal patterns intermediate between the two species, raises doubts as to the validity of pupal gill filament number for separating closely related species. Difficulties in identification of *S. oyapockense* and *S. roraimense* on the Guyana border of eastern Brazil (R. Maú, Arraia, Takutu) where scutal patterns are similar and platelet form and abdominal tergite III differences are not species-specific, further illustrate the difficulties in the *amazonicum* group. These data suggest that species in the *S. amazonicum* group in the Amazon basin are in a state of incipient speciation that can only be effectively understood by integrating taxonomic techniques using cytology as the base.

An additional character used by Py-Daniel (1983) to differentiate *S. roraimense* from *S. oyapockense* was the presence of membranous striations on the posterior two thirds of pupal sternite IV in only the former species. This character is very difficult to observe and might be artefactual.

Simulium (Psaroniocompsa) incrustatum Lutz

(Colour Plate 2, Fig. 27; Colour Plate 3, Fig. 121; Figs 13,40, 51, 62, 73, 84, 95, 106, 139, 151, 162, 173, 184, 198, 199, 217, 229, 242, 253)

Simulium incrustatum Lutz, 1910: 243. LECTOTYPE pupa [here designated], BRAZIL, Minas Gerais, Mendes (no collector indicated) (no collection date). (IOC)

Psaroniocompsa opalinifrons Enderlein, 1934b: 192. LECTOTYPE ♀, PARAGUAY: San Bernardino (*Fiebrig*) (no collection date) (ZMHU, NMV) by designation of Wygodzinsky 1951: 218. [Synonymy with *S. incrustatum* Lutz by Vargas & Diaz Najera, 1953a: 138]

Simulium yarzabali Ramírez Pérez, 1980: 66. HOLOTYPE ♀, VENEZUELA: Territorio Federal Amazonas, Departamento de Atabapo, Sierra de Parima, Mayuwëteri, 1050m, 1975–80 (collector presumably *J. Ramírez Pérez*) (IND). [Synonymy

with *S. incrustatum* Lutz by Ramírez Pérez, 1983: 9; revalidation by Shelley *et al.*, 1987a: 463.]

Simulium aequifurcatum Lutz, 1910: 259. HOLOTYPE pupa, BRAZIL (no collection locality, collector or collection date given) (IOC). **New synonymy**

The following descriptions are based on specimens from the onchocerciasis focus unless indicated otherwise.

FEMALE. General body colour black (brown in older faded specimens). Body length 2.0–2.9 mm ($\bar{x}$=2.3 mm, s.d.=0.2, n=24); wing length 1.7–2.3 mm ($\bar{x}$=1.9 mm, s.d.=0.2, n=24); wing width 0.7–1.1 mm ($\bar{x}$=0.9 mm, s.d.=0.1, n=24).

Head dichoptic with dark red eyes (appearing black in dried specimens); nudiocular area only slightly developed (Fig. 40). Frons, clypeus and occiput black with silvery grey pruinosity and scattered, short, black hairs. Mouthparts dark brown. Antennae black, except scape and pedicel, light brown to orange. Cibarium with highly sclerotised posterior margin and deep central trough with central area invaginated and covered in blunt tubercles; groups of teeth in several rows either side of trough extending on to base of cornuae (Fig. 51).

Scutum and humeri velvet black, sometimes with faint, median pale line. Scutum with numerous recumbent, brass-coloured, almost scale-like hairs, arranged in median line on anterior half of scutum in freshly emerged specimens and in small groups on rest of scutum. Pair of submedian, silver pruinose triangles, as wide at maximum width as long, on anterior scutal border and extending for one fourth of scutal length (more obvious with posterior illumination). Posterior and lateral margins of scutum and humeri silver pruinose. Paranotal folds velvet black with silver pruinosity (Colour Plate 2, Fig. 27). Pleural region black and dark brown with grey pruinosity. Scutellum velvet black with recumbent, brass-coloured setae and row of long black bristles on posterior border, 1+1 groups of bristles on postero-lateral borders. Postnotum black with grey pruinosity.

Costa with relatively sparse distribution of spines and fine setae; subcostal vein of wing bare; basal section of Radius bare, distal half with 6–14 spines and fine setae (Fig. 62). Costal base tuft of dark setae and small group of narrow dark scales at base of costa.

Fore legs with coxa, trochanter and femur mid to dark brown, tibia pale to mid brown, tarsus dark brown to black; outer face of tibia white pruinose. Mid leg mid to dark brown with basal articulation of tibia, basitarsus and basal half of second tarsal segment pale brown; outer face of tibia white pruinose. Hind leg black with basal third to half of tibia, basal three quarters of basitarsus and basal half of second tarsal segment cream (Colour Plate 2, Fig. 27). Tarsi narrow as in *S. exiguum* (Fig. 2). Femora and tibiae of all legs with scales as in *S. exiguum* (Fig. 4). Claws curved with small basal tooth (Fig. 73). Halteres yellow with reddish tinge at capitulum base and dark brown stem.

Abdominal tergite I velvet black with fringe of long and short, dark hairs; tergites II–V greyish-black with velvet black strip on anterior half, sometimes velvet black area confined to tergal plate on tergites IV and V. Tergite II with silver pruinosity covering velvet black region and tergite III with silver pruinosity confined to anterior margin. Tergites VI–IX greyish-black (Colour Plate 2, Fig. 27). Tergal plates well developed as in *S. exiguum* and shiny black (Fig. 5). Sternites and genitalia dark brown to black. Eighth sternite sclerotised with a group of 3–9 poorly developed setae and 5–15 well developed setae on each side; gonopophyses small, membranous and setose, with light sclerotisation at base of inner margin (Fig. 84). Cerci hemispherical, paraprocts subrectangular with small underlying flap on outer margin (Fig. 95). Genital fork (Fig. 106) thin and lightly sclerotised, with well developed lateral processes on arms and fine, poorly developed anterior processes. Spermatheca oval with hexagonal, internal pattern and well developed internal spicules arranged in groups. Area of insertion of spermathecal duct membranous and between one third and a quarter the maximum width of spermatheca.

MALE. General body colour black. Body length 1.9 mm, wing length 1.6 mm, wing width 0.7 mm (n=1). Specimens from São Paulo and Santa Catarina states: body length 2.2–2.9 mm ($\bar{x}$=2.5 mm, s.d.=0.29, n=4), wing length 1.7–2.4 mm ($\bar{x}$=2.1 mm, s.d.=0.27, n=11), wing width 0.8–1.3 mm ($\bar{x}$=1.0 mm, s.d.=0.16, n=11).

Head holoptic with upper eye facets dark red and lower eye facets darker red (appearing black in dried specimens). Rest of head coloration as in female.

Scutum velvet black with recumbent, golden hairs many of which are wide in anterior half (Colour Plate 3, Fig. 121). Humeri velvet black with silver pruinosity in narrow band across anterior margin. Scutum with posterior and lateral margins pruinose as in female. Coloration of paranotal folds and pleural area as in female except silver pruinosity more developed. Coloration and setation of scutellum and postnotum as in female.

Wing venation, leg and halter coloration (Colour Plate 3, Fig. 121) as in female.

Abdominal tergites velvet black, basal fringe of long black hairs. Silver pruinose ornamentation as follows: tergite II completely silver except for median area; tergites IV–V with 1+1 small silver spots on antero-lateral margins; tergite VI completely silver except for postero-median area; tergites VII–VIII with lateral margins silver (Colour Plate 3, Fig. 121). Genitalia dark brown, sternites brownish grey; sternal plates well developed. Gonocoxite approximately as long as wide; gonostyle short, slightly

longer than wide, and about quarter size of gonocoxite, with prominent subterminal spine (Fig. 139). Ventral plate lightly sclerotised with thick basal arms; keel area covered in thick, fleshy spines rather than hairs, most developed towards apex (Fig. 151). Median sclerite at least twice as long as maximum width at centre (Fig. 162). Paramere with large distal group of at least 20 tightly packed spines of varying size (Fig. 173).

PUPA. Cocoon length dorsally 2.3 mm, n=1; ventrally 2.8 mm, n=1; pupa length (no full pupae available); gill length 2.4–3.7 mm ($\bar{x}$=3.2 mm, s.d.=0.6, n=4). Specimens from São Paulo State: cocoon length dorsally 2.5–3.5 mm ($\bar{x}$=2.9 mm, s.d.=0.23, n=22); ventrally 2.8–3.6 mm, ($\bar{x}$=3.1 mm, s.d.=0.22, n=22); pupa length 2.4–3.2 mm ($\bar{x}$=2.7 mm, s.d.=0.2, n=22); gill length 2.4–3.8 mm ($\bar{x}$=3.1 mm, s.d.=0.34, n=30).

Cocoon slipper-shaped, light to dark brown; rim of aperture slightly reinforced, without central protuberance (Fig. 184). Cocoon delicate, composed of elastic, amorphous substance interwoven with fibres. Gill light brown with six forwardly-directed long, slender filaments; primary branches in vertical plane and dorsal and median secondary branches in approximately same horizontal plane with ventral branch below (Fig. 198). Main trunk of gill giving rise to two primary branches near base; dorsal primary branch with bifurcation in basal third of gill (usually in basal quarter to third), each secondary filament further bifurcating in about middle of gill, ventral primary branch with bifurcation at about one third the gill length; filaments slender, rounded distally, their surfaces covered in fine spicules and margins crenate. Head (frontoclypeus) with 2 + 2 well developed bifid frontal trichomes (the anterior median to posterior) and 1 + I well developed bifid facial trichomes; surface of head covered with platelets. Thorax with 5 + 5 well developed bifid trichomes, 2 + 2 simple well developed trichomes beneath gill base towards margin and 1 + 1 simple trichomes centrally; surface of thorax covered with platelets, more densely distributed in anterior half. Abdominal tergite I with 1 + 1 strong, simple hairs centrally; tergite II with 3+3 simple hairs in line along central region of segment and 1+1 groups of 2–3 simple hairs at outer end of intial row; tergites III–IV with 4 + 4 simple hooks and 1 + 1 weak hairs above (and sometimes inside) outer most; tergite V with or without patch of weak spine combs at antero-lateral margin; tergites VI–VIII with patches of well developed spines and spine combs on antero-lateral margins; tergite IX with 1 + 1 strong, unbranched terminal spines and antero-lateral patches of spines and spine combs. Abdominal sternites III–IV with central patch of fine spine combs, extending over most of segment in sternite IV; sternite V with 2 + 2 simple or bifid hooks towards posterior border; sternites VI–VII with 4+4 evenly spaced simple or bifid hooks and 1 + 1 large patches of spine combs above and outside inner two; sternite VIII with wide band of fine spine combs.

MATURE LARVA. Body length 2.7 mm (n=1); width of head capsule 0.3 mm (n = 1); length of head capsule 0.5 mm (n=1). Specimens from southern Brazil-body length 3.5–5.0 mm ($\bar{x}$=4.1 mm, s.d.=0.48, n=20); width of head capsule 0.4–0.5 mm ($\bar{x}$=0.4 mm, s.d.=0.04, n=19); length of head capsule 0.5–0.6 mm ($\bar{x}$=0.6 mm, s.d.=0.05, n=19). Body colour white with greyish brown markings (Fig. 217). Coloration in Carnoy's is similar except that the banding patterns are more distinct. Body form as in Fig. 217 with fine, short, palmate setae on the dorsal surface of the thorax and abdomen, more dense on the latter (Fig. 13); these setae appear simple under the light microscope.

Head yellow with light brown positive head spot pattern (Fig. 229). Head capsule with numerous, randomly distributed setae on all surfaces. Postgenal cleft longer than wide, pointed anteriorly and constricted at base, so that maximum width is at about third of length; postgenal bridge between half and third as long as hypostomium (Fig. 242). Hypostomium with strongly pigmented anterior margin and nine distinct apical teeth whose bases lie in horizontal line; corner and median teeth large, intermediate teeth less well developed; 5–7 lateral serrations with hindmost well beyond level of first hypostomial setae; 1 + 1 groups of 4–5 hypostomial setae lying parallel to lateral margins of hypostomium, although penultimate seta often out of line with others; surface of hypostomium with few short setae (Fig. 253). Antennae pale brown with segment ratios 1:1:I (n=7). Mandible with two mandibular serrations, anterior larger, posterior very reduced; at least first three comb teeth of approximately equal size. Maxillary palp short, about three times as long as breadth at base. Cephalic fan with 31–32 rays (n=3) (material from southern Brazil with 27–45 rays (n=26)).

Thorax white with grey pigment dorsally covering almost all surface, ventrally with a median patch of grey chromatocytes anterior to proleg and similar patches at base of proleg and posterior to this forming bands. Proleg (see Fig. 15) with lightly sclerotised plates with 11 processes (n=1) (material from southern Brazil with 12–18 processes (n=8)). Pupal respiratory histoblasts dark brown and claviform.

Abdomen white with grey rings on first four narrow anterior segments, posterior expanded segments completely grey dorsally and with pattern ventrally. Ventral papillae well developed. Cuticle with small setae covering dorsal surface. Anal sclerite with well sclerotised arms; posterior arms extending to row 12 of posterior circlet. Posterior circlet with 59–65 hooks, (n=3) (specimens from southern Brazil with 61–63 rows of 2–12 hooks (n=4)). Anal gill tri-lobed with 4–11 lobules per lobe.

Variation

The above descriptions are based on specimens from the Brazilian part of the Amazonia focus. Observed variation between the focus populations is as follows: females from the type-locality in southern Brazil and from Santa Catarina have leg coloration lighter than Amazon and Ecuador populations. The Sc in *incrustatum* is hairy along the basal two thirds in material from the type locality, but not in populations from Santa Catarina in southern Brazil or in the onchocerciasis focus where the Sc is bare. The thoracic tomentum is also variable in colour. Both these variations have been found in material from Argentina described by Coscarón & Wygodzinsky (1973).

Considerable variation has been observed in the branching of pupal gill filaments. The levels at which the two most distal bifurcations of the dorsal primary branch and the bifurcation of the ventral primary branch occur in relation to one another is variable even between the left and right gill of the same specimen, although the bifurcation of the ventral primary branch occurs below or level with the secondary bifurcations of the dorsal branch. Similar variations are figured by Coscarón and Wygodzinsky (1973) with material from Argentina. In the Ecuador satellite focus of the R. Canandé at Naranjal pupal cocoons are more fragile and lighter and pupae have darker filaments.

Larvae also vary in colour. The dark banded form of larva from Ecuador could be confused with *S. exiguum*, but the ventral papillae, many small setae on the dorsum and very positive head pattern in *S. incrustatum* enable them to be distinguished. Larval variation occurs in Santa Catarina in southern Brazil where the grey pattern ranges from almost imperceptible to dark brown or green; larvae with light or dark pigmentation also occur in which the first grey ring of the abdomen is prominent in relation to the others.

Taxonomic discussion

Simulium incrustatum was first described by Lutz in 1910 from various localities in south-east Brazil. Type material consists of a series of slides of syntype pupae and adults. We have selected and marked as lectotype a single pupal pelt of four mounted on a slide from Mendes, Rio de Janeiro.

Simulium incrustatum has been the subject of many redescriptions and taxonomic discussions (references listed in Coscarón & Wygodzinsky (1984)). *Psaroniocompsa opalinifrons* described by Enderlein (1934b) from Paraguay was first synonymised with *S. incrustatum* by Vargas & Díaz Nájera (1953a). Initially, this synonymy was not accepted by Coscarón & Wygodzinsky (1973) in their revision of *Simulium (Psaroniocompsa) opalinifrons*, but having studied variation in these two species Coscarón (1987, 1991) and Coscarón & Wygodzinsky (1984) then accepted the original synonymy. *Simulium yarzabali* was described from the onchocerciasis focus in Venezuela by Ramírez Pérez (1980) but later synonymised with *S. incrustatum* (Ramírez Pérez, 1983). Later, Shelley *et al.* (1987a) revalidated *S. yarzabali* on the basis of morphological differences in the subcostal wing vein and in behaviour. Our subsequent examination of *S. incrustatum* from localities in Ecuador and southern Brazil has shown wide variation in morphological characters in *S. incrustatum* (see section on variation). Therefore, we now support the synonymy of *S. yarzabali* with *S. incrustatum* by Ramírez Pérez (1983) as did Coscarón (1987, 1991). The morphological and behavioural differences in populations of *S. incrustatum* suggest the presence of a species complex. Until cytotaxonomic studies are made the value as interspecific characters of the morphological variations described above cannot be assessed.

Shelley *et al.* (1987a) reviewed the literature on *S. incrustatum* as an anthropophilic species and possible vector of onchocerciasis in the Amazonia focus. They were unable to distinguish females of *S. incrustatum* and *S. limbatum* on the limited material available. We have now obtained reared material of *S. limbatum* from Roraima State, Brazil and compared this with the type from the Rupununi river, Guyana in the BMNH collection. *Simulium limbatum* can be distinguished from *S. incrustatum* as follows: female *limbatum*-with a posterior light source the pair of submedian silver triangles are more obvious and extend for two thirds the scutal length ending in tails; with an anterior light source triangles are equilateral and black (Colour Plate 2, Figs 28, 29). Leg coloration is the same as the southern form of *S. incrustatum*. Thorax dimensions of *S. incrustatum* from the focus and southern Brazil and *S. limbatum* showed no differences (maximum thoracic length: maximum thoracic width, *S. incrustatum* 'focus' 0.98–1.14 mm, $\bar{x}$=1.04 mm, s.d.=0.04, n=16; *S. incrustatum* 'southern Brazil" 0.88–1.11 mm, $\bar{x}$=1.01 mm, s.d.=0.06, n=16; *S. limbatum* 0.97–1.22 mm, $\bar{x}$=1.04 mm, s.d.=0.07, n=15. Male *S. limbatum* can be distinguished by the presence of a pair of submedian silver (posterior lighting) or black (anterior lighting) triangles in anterior third of the scutum (Colour Plate 3, Figs 122, 123), which are absent in *S. incrustatum*. No major differences were noted between the pupa and larva of *S. limbatum* and that of *S. incrustatum*. Based on this new assessment we consider *S. limbatum* to be absent from the Brazilian part of the Amazonia focus. However, Ramírez Pérez's (1983) and Ramírez Pérez's *et al.* (1982) records of its presence at Boca de Mavaca and Platanal in the lowlands as well as in the Parima mountains in Venezuela need to be confirmed.

The validity of another species, *S. aequifurcatum*, has also been doubtful because of its similarity to *S. incrustatum* and *S. limbatum*. *Simulium aequifurcatum*

was described superficially by Lutz in 1910 from a single pupa of unknown provenance in Brazil and thought by the author to be possibly a form of *S. incrustatum* in which the branch heights of the pupal gill were all at the same level. In 1962 Vulcano synonymised *S. aequifurcatum* with *S. brevifurcatum* Lutz having examined type material of both species in the Oswaldo Cruz collection. In their revision of the subgenus *Psaroniocompsa*, Coscarón & Wygodzinsky (1984) revalidated *S. aequifurcatum* based on their examination of the type material and placed the names *S. machadoi* Ramírez Pérez and *S. machado-allisoni* Ramírez Pérez and *S. meruoca* Nunes de Mello, Almeida & Dellome Filho as junior synonyms [see Shelley *et al.* (1984) for explanation of synonymies of these three names with *S. limbatum* Knab]. Coscarón described *S. aequifurcatum* from reared material from several diverse sites and distinguished his interpretation of this species from *S. incrustatum* on adult coloration and pupal morphology and suggested *S. limbatum* as a possible junior synonym. Coscarón (1987, 1991) followed his earlier synonymies. Crosskey (1988) cited these three names as synonyms of *S. limbatum* as in Shelley *et al.* (1984) and indicated *S. yarzabali* as a possible synonym. We have now examined the holotype pupa of *S. aequifurcatum* and consider it synonymous with *S. incrustatum*. The left hand gill of *S. aequifurcatum* (Fig. 200) has all three most distal bifurcations at approximately the same level: about one third the distance from the gill base to its most distal point, whereas the right hand gill (Fig. 201) has these bifurcations at different levels, a configuration seen at the same level in the right hand gill of the lectotype of *S. incrustatum* (Fig. 199). The configuration and level of branching in the *S. incrustatum* gill is highly variable and the form seen in *S. aequifurcatum* was found in material collected from Santa Catarina state in southern Brazil. The broad range of variations in gill form has already been figured for *S. incrustatum* (as *opalinifrons*) in Coscarón & Wygodzinsky (1973). The pupa of *S. limbatum* differs from *S. incrustatum* and *S. aequifurcatum* in that the gill filaments are more robust and branching is less variable, occurring in the basal fourth or fifth of the gill (Fig. 202). The provenance of *S. aequifurcatum* is unknown so prospecting for further specimens is impossible.

Coscarón (1991), Crosskey [1988] and Shelley (1988b) place *S. incrustatum* in the subgenus *Psaroniocompsa*.

Distribution

This species has a more restricted distribution in the Brazilian part of the focus, being found in large numbers only at the highland localities of Auaris and Serra dos Surucucus (FUNAI post and Dalem) and in low numbers at Mucajai in the lowlands (Table 1). The closely related *S. limbatum* was not found on the Brazilian side of the focus, only occurring in adjacent savannas near Boa Vista. In the Venezuelan part of the focus *S. incrustatum* [as *S. yarzabali*] has only been collected breeding in shaded rivers and biting man (Table 2). Larvae and pupae collected by Basañéz (see Basañéz *et al.*, 1989) at Parima were identified by one of us (A.J.Shelley) as *S. incrustatum*. Ramírez Pérez *et al.* (1982) report the presence of *S. limbatum* in both highland and lowland localities in Venezuela (Table 2) but do not state the stages collected at each locality. Therefore, reports on the vectorial status of *S. incrustatum* in Venezuela (Basáñez *et al.*, 1989) could include *S. limbatum* and further work is needed to verify identifications.

Simulium incrustatum is a widespread species occurring in various Brazilian States (Material Examined) and in other countries of South America: Argentina, Brazil, Ecuador, Paraguay, Trinidad and Venezuela (Material Examined, Coscarón, 1987, 1991; Coscarón & Wygodzinsky, 1973).

Simulium (Psilopelmia) bipunctatum Malloch

(Colour Plate 2, Fig. 30; Colour Plate 4, Fig. 124; Figs 41, 52, 63, 74, 85, 96, 107, 140, 152, 163, 174, 185, 203, 218, 230, 231, 243, 254)

Simulium bipunctatum Malloch, 1912: 650. HOLOTYPE ♀, PERU: Rio Charape, 13.ix.1911 (*C.H.T. Townsend*) (USNM, Cat.No.15305). [examined]. [Synonymised with *S. dinellii* Joan by Knab, 1913: 155; revalidated by Coscarón, 1985: 320.]

Simulium antillarum Jennings, 1915: 200. LECTOTYPE ♂, VIRGIN ISLANDS: St Croix Island, 1.5 miles west of West End, Frederiksted, 24.xi.1913 (*A.H. Jennings*) (USNM Cat.No.19997) by designation of Stone (1969: 313). [examined]. [Synonymy by Shelley *et al.*, 1989: 90.]

Simulium wolcotti Fox, 1953: 138. HOLOTYPE ♂, PUERTO RICO: Henry Barracks, near Cayey, 1950 (*I. Fox*) (STMPR). [Synonymised with *S. antillarum* Jennings by Stone, 1969: 313; synonymised with *S. bipunctatum* Malloch by Shelley *et al.*, 1989a: 90.]

Simulium pseudoantillarum Ramírez Pérez & Vulcano, 1973: 379. SYNTYPES 1 ♀, 1 ♂, VENEZUELA: Monagas State, San Antonio de Maturin, (no collection date) (*Ramírez Pérez & Vulcano*) (DDSV). [Synonymy by Shelley *et al.*, 1989a: 90.]

The descriptions are based on specimens from Ecuador because of the paucity of material collected in the Amazonia focus.

FEMALE. General body colour orange. Body length

2.2–3.5 mm ($\bar{x}$=2.7 mm, s.d.=0.35, n=17), wing length 2.2–2.6 mm ($\bar{x}$=2.4 mm, s.d.=0.12, n=18), wing width 1.0–1.2 mm ($\bar{x}$=1.0 mm, s.d.=0.06 mm, n=18). Igarapé Tiquié, Brazil-body length 1.3–2.8 mm ($\bar{x}$=2.0 mm, s.d.=0.39, n=16), wing length 1.6–2.1 mm ($\bar{x}$=1.9 mm, s.d.=0.14, n=19), wing width 0.7–1.0 mm ($\bar{x}$=0.8 mm, s.d.=0.07, n=19).

Head dichoptic with red eyes (appearing black in dried specimens); nudiocular area poorly developed (Fig. 41). Frons, clypeus and occiput black with silver pruinosity. Mouthparts black. Antennae orange with distal third to half dark brown. Cibarium with central trough unarmed and sclerotised and a group of about 20 small teeth forming a protuberance on each side of trough (Fig. 52).

Scutum yellowish with three prominent longitudinal orange bands that coalesce posteriorly; median band commences on anterior border of scutum and occupies three-quarters of its length; the pair of lateral bands commence in the second quarter of the scutum and continue to posterior margin. Scutum with a pair of submedian silver comma-shaped marks commencing at interface between yellow anterior margin and orange area and running half length of scutum. Lateral margins of scutum yellow and faintly pruinose. Paranotal folds orange-brown in fresh specimens, often becoming dark brown in preserved material. Scutum with numerous adpressed black setae lying singly (Colour Plate 2, Fig. 30). Pleural region varying from light orange to mid brown with faint silver pruinosity. Scutellum and postnotum orange; posterior margin of scutellum with erect black bristles.

Subcostal wing vein with line of setae almost to distal extremity, basal section of Radius with two or three irregular rows of setae (Fig. 63). Costal base tuft dark brown.

Fore leg coxae, trochanters and femora of all legs orange to light brown; coxae of mid and hind legs light brown on anterior half, dark brown on posterior half; tibiae and tarsi of all legs dark brown. Mid and hind leg femora and tibiae with darker distal articulations (Colour Plate 2, Fig. 30). Tarsi narrow as in *S. exiguum* (Fig. 2). Claws curved with large basal tooth (Fig. 74). Halteres yellow with light brown stems.

Abdominal tergites from orange to brown depending on age of specimen and whether it has blood fed; older blood fed specimens tend to become dark brown. Tergites I–IV usually mottled light brown and yellow but can be yellowish orange, particularly in reared material, occasionally mid brown; tergite V usually matt grey but sometimes matt black; tergites VI–IX dull mottled mid and light brown but sometimes completely shiny brown or black (Colour Plate 2, Fig. 30). Tergal plates well developed as in *S. exiguum* (Fig. 5) and generally light brown, sometimes dark brown. Sternites and genitalia orange to light brown becoming dark brown in preserved specimens. Eighth sternite usually lightly sclerotised with 20–24 setae on each side (Fig. 85); gonopophyses small, membranous with minute hairs on inner margin. Cerci hemispherical; paraprocts with pronounced ventral extension (Fig. 96). Genital fork (Fig. 107) slender with well developed triangular anterior processes. Spermatheca similar to that of *S. exiguum* (Fig. 6), oval, sclerotised, with surface covered in regular rounded depressions and spicules of inner surface randomly arranged; area of insertion of spermathecal duct membranous and a third as wide as maximum width of spermatheca.

MALE. General body colour orange. Body length 1.8–3.2 mm ($\bar{x}$=2.4 mm, s.d.=0.46, n=9); wing length 1.8–2.4 mm ($\bar{x}$=2.2 mm, s.d.=0.19, n=17); wing width 0.8–1.2 mm ($\bar{x}$=1.0 mm, s.d.=0.11, n=17).

Head holoptic with red eyes. Clypeus black with silver pruinosity. Rest of head coloration as in female.

Coloration and hairing of scutum, pleural region, scutellum and postnotum as in female (Colour Plate 4, Fig. 124).

Subcostal wing vein bare or with variable number of setae (1–7) in central portion, basal section of Radius with single row of setae.

Leg coloration and halter (Colour Plate 4, Fig. 124) as in female.

Abdominal tergites I–IV mottled orange and light brown; tergites V–IX and genitalia light brown; basal tuft of light orange hairs. Silver ornamentation as follows: tergites VI and VII with a pair of submedian silver pruinose patches, anterior margin of tergite II and all of tergite IX faintly pruinose (Colour Plate 4, Fig. 124). Sternites I–IV light orange, V–IX dark brown; sternal plates well developed only on segments V–VIII. Genitalia orange to light brown. Gonocoxite longer than wide; gonostyle small, half the length of the gonocoxite, curved and conical with apical spine (Fig. 140). Ventral plate (Fig. 152) with reduced and lightly sclerotised basal arms and a small keel; hairs long and covering most of ventral plate. Median sclerite (Fig. 163) slightly longer than wide with deep apical incision occupying about half the length of the sclerite. Paramere as in Fig. 174 with few, well developed, mainly apical spines and several smaller spines.

PUPA. Cocoon length dorsally 2.3–3.2 mm ($\bar{x}$=2.7 mm, s.d.=0.22, n=17); ventrally 2.4–3.9 mm ($\bar{x}$=3.1 mm, s.d.=0.39, n=17); pupa length 1.7–2.9 mm ($\bar{x}$=2.4 mm, s.d.=0.32, n=17); gill length 1.4–3.0 mm ($\bar{x}$=2.3 mm, s.d.=0.36, n=32).

Cocoon slipper-shaped, dark brown; rim of aperture dark brown, reinforced and usually without median protuberance (Fig. 185). Cocoon composed of thick threads producing an open weave, particularly laterally at point of adhesion to substrate. Gill light brown with eight forwardly directed slender filaments arranged irregularly in a vertical plane (Fig. 203): main trunk giving rise to three primary branches, ventral

with two filaments and median and dorsal each with three filaments; filaments arise basally on all primary branches; filaments slender with crenated margins and rounded distally, their surfaces covered with fine spicules. Head (frontoclypeus) with 2+2 frontal and 1+1 facial bifid or trifid well developed trichomes; surface of head with sparsely distributed platelets. Thorax with 5+5 trichomes on anterior border, each with two to five trichomes, 1+1 postero-dorsal and 1+1 ventral unbranched trichomes. Surface of thorax covered with platelets mainly concentrated around the dorsal region. Abdominal tergites II–IV with 4+4 simple hooks, more weakly developed on segment II, VI–IX with spine combs on anterior margins, tergite IX with 1+1 strong unbranched spines; sternite IV in female with 2+2 simple hooks, in male reduced to fine setae, sternites V–VII with 2+2 simple to bifid hooks; 1+1 patches of spine combs on postero-lateral borders of sternites IV–VIII.

MATURE LARVA. Body length 4.2–5.4 mm ($\bar{x}$=4.8 mm, s.d.=0.34, n=20); width of head capsule 0.4–0.6 mm ($\bar{x}$=0.5 mm, s.d.=0.04, n=20); length of head capsule 0.5–0.7 mm ($\bar{x}$=0.6 mm, s.d.=0.05, n=20). Body colour grey in both alcohol and Carnoy's preserved specimens (Fig. 218). Body form as in Fig. 218.

Head yellow with brown markings and several scattered minute setae on all surfaces. Head pattern negative as in Fig. 231, consisting of a central clear area and 1+1 antero-lateral and 1+1 postero-lateral clear areas of head spots within a dark background confined to the posterior half of the cephalic apotome. More rarely the head pattern may be positive in Ecuador (Fig. 230). Postgenal cleft large, longer than wide, with pointed anterior margin usually reaching posterior margin of hypostomium; postgenal bridge highly reduced or absent (Fig. 243). Hypostomium as in Fig. 254. Antennae long, brown and with segment ratios 12:14:17. Mandible with one to three mandibular serrations, of which anterior is usually larger. Maxillary palp short, about twice as long as breadth at base. Cephalic fan with 34–42 rays.

Thorax whitish grey dorsally, darker grey ventrally, either diffuse or concentrated into one to three central patches posterior to the proleg. Cuticle with minute scattered hairs on dorsal and lateral surfaces. Proleg (see Fig. 15) with plates lightly sclerotised with 10–12 processes. Pupal respiratory histoblast dark brown and claviform.

Abdomen whitish with four grey bands encircling the body on the four (narrow) anterior segments, bands more obvious dorsally; posterior (wide) segments of abdomen brownish grey dorsally and whitish laterally and ventrally. Ventral papillae small. Cuticle with few, minute scattered hairs on dorsal and lateral surfaces as in thorax but slightly more frequent on postero-dorsal region. Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with about 62–71 rows of 1–12 hooks. Anal gill tri-lobed, each lobe with 4–7 short, secondary lobules .

Taxonomic discussion

Coscarón (1987) treated *S. antillarum, S. bipunctatum* and *S. pseudoantillarum* as distinct species in the subgenus *Ectemnaspis* but Crosskey (1988) placed all three names in the subgenus *Psilopelmia* with *bipunctatum* as a synonym of *S. dinellii*. *Simulium antillarum* and *S. pseudoantillarum* were synonymised under *S. bipunctatum* in the subgenus *Psilopelmia* by Shelley *et al.* (1989a), who dealt with the subject in detail.

Distribution

This species was infrequently collected biting man at Auaris and Parima in the Amazonia focus. In South America the species occurs in northern Brazil, Colombia, Ecuador, Peru and northern and southern Venezuela. In Central America it has been reported from the following Caribbean Islands: Cuba, Dominica, Guadeloupe, Jamaica, Montserrat, Puerto Rico, St Croix, and Trinidad as well as from mainland Mexico (Shelley *et al.*, 1989a).

Simulium (Psilopelmia) iracouboense Floch & Abonnenc

(Colour Plate 2, Fig. 31; Colour Plate 4, Fig. 125; Figs 42, 53, 64, 75, 86, 97, 108, 141, 153, 164, 175, 186, 204, 219, 232, 244, 255)

Simulium iracouboense Floch & Abonnenc, 1946c: 7. LECTOTYPE ♀ [here designated] and associated pupal pelt, FRENCH GUIANA, Cafesoca, R. Oyapock. (5.6.46) (E. Abonnenc?) (IP).

Simulium sucamense Nunes de Mello, 1974: 41. HOLOTYPE ♀, BRAZIL: Território Federal de Roraima, Boa-Vista to Bonfim road, Igarapé Surrão, xii.1972 (*Nunes de Mello, J. A. & Vieira da Silva, E.*) (INPA). [Synonymised with *S. iracouboense* Floch & Abonnenc by Py-Daniel, 1989: 254]

Simulium santaelenae Ramírez Pérez & Peterson, 1981b: 161. HOLOTYPE ♀, VENEZUELA: Estado Bolívar, Distrito Roscio, Santa Elena de Uairén, (no collection date or collector) (IND). [Synonymy with *S. sucamense* by Ramírez Pérez, 1983: 20; synonymy with *S. samboni* Jennings by Shelley *et al.*, 1984: 155; synonymy with *S. iracoubense* Floch & Abonnenc by Py-Daniel, 1989: 254.]

FEMALE. General body colour orange. Body length 1.4–2.3 mm ($\bar{x}$=1.9 mm, s.d.=0.3, n=9); wing length 1.3–1.7 mm ($\bar{x}$=1.5 mm, s.d.=0.1, n=9), wing width 0.6–0.8 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=6).

Head dichoptic with dark red eyes (appearing black in dried specimens); nudiocular area well developed (Fig. 42). Frons, clypeus and occiput dark brown with silver pruinosity; frons with single row of hairs along lateral margin. Clypeus and occiput with many scattered, golden setae. Mouthparts brownish orange to mid brown. Antennae pale orange, covered in fine hairs and slightly pruinose. Cibarium with well developed and highly sclerotised cornuae, poorly sclerotised in central region and lacking central trough; 1+1 submedian groups of small teeth extending towards base of each cornua (Fig. 53).

Scutum orange with numerous brown setae (which look golden at some angles of illumination); pair of submedian silvery white vittae extending from anterior to posterior margins, wider at both margins (most obvious with anterior illumination). Posterior margin without pruinosity, lateral margins pruinose (Colour Plate 2, Fig. 31). Humeri slightly darker than remainder of scutum. Scutellum orange with long dark hairs along posterior margin, interspersed with shorter, recumbent, yellow hairs. Postnotum orange with pair of submedian brown patches at anterior margins, extending towards postero-lateral margins; anterior margin slightly pruinose. Paranotal folds orange with thin brown line highlighting lower margin. Pleural region yellow, lightly pruinose; some of thoracic sclerites with brown highlights at margins; small lightly pigmented patch above mid coxa.

Subcostal vein with row of 5–7 hairs on basal three-quarters. Radius with hair-like setae along entire length; first spine-like seta occurs at approximately mid point of vein (Fig. 64). Costal base tuft of few dark hairs.

Legs yellow, with dark brown bands as in Colour Plate 2, Fig. 31. Fore leg with distal four-fifths of fore basitarsus and remaining tarsi dark brown; mid leg with inner margin of coxa dark brown, distal tip of tibia pale brown, distal third of all tarsi mid brown; hind leg with distal tip of femur darker, varying from mid to dark brown, distal half of tibia, distal third of hind basitarsus and distal half of second tarsi, and remaining hind tarsomeres dark brown. Tarsi narrow as in *S. exiguum* (Fig. 2). Scale-like hairs present on femur and tibia of all legs as in *S. exiguum* (Fig. 4). Claws slender and curved, with blunt, rounded basal tooth (Fig. 75). Halteres cream with yellow to pale brown stems.

Abdomen with chequer board appearance (Colour Plate 2, Fig. 31). Tergite I yellow with basal fringe of long pale hairs; tergite II yellow; tergites III–VI yellow with prominent dark brown central spot which is progessively larger on each segment and 2 + 2 smaller, pale brown lateral spots, the outermost being less distinct; tergite VII without central spot, but with central tergal area shiny and both pairs of pale, submedian spots present; tergites VIII–IX yellow. Lateral spots on tergites III–VI & VII often masked by underlying grey coloration. Tergal plates not generally well developed. Sternites pale grey or dirty yellow except central regions of sternites I–III, which are always yellow. Genitalia yellowish to pale brown, except cerci which are mid to dark brown. Eighth sternite very lightly sclerotised with group of 11–14 setae, inner 4–7 setae weakly developed and outer 6–8 well developed. Gonopophyses triangular, small, membranous with minimal sclerotisaton on inner margin; posterior tip with few minute hairs which are abundant on lower region (Fig. 86). Cerci roughly square with rounded corners, dark to mid brown; paraprocts long and membranous with one well developed anteriorly-directed process (Fig. 97). Genital fork well developed with lightly sclerotised stem; anteriorly directed processes long and narrow (Fig. 108). Spermatheca slightly ovoid, sclerotised, lacking external sculpturing, but with spicules arranged in short irregular rows of 3–5; width of membranous area of insertion of spermathecal duct large, about one third maximum width of spermatheca.

MALE. General body colour orange. Body length 1.6–2.3 mm ($\bar{x}$=1.9 mm, s.d.=0.2, n=14); wing length 1.3–1.8 mm ($\bar{x}$=1.6 mm, s.d.=0.1, n=15), wing width 0.4–1.0 mm ($\bar{x}$=0.7 mm, s.d.=0.2, n=8).

Head holoptic with dark red upper eye facets and darker red lower eye facets (appearing black in dried specimens). Clypeus, occiput, mouthparts and antennae as in female.

Scutum orange with numerous, short, rust-coloured setae, appearing golden under certain illumination; pair of small, submedian silver pruinose triangles extending posteriorly as vittae from anterior margin for one third length of scutum (best seen with anterior light source) and pair of similarly shaped vittae extending anteriorly from posterior margin for over one third length of scutum (most visible with posterior lighting); lateral margins pruinose. Humeri orange. Scutellum, postnotum, paranotal folds and pleural region as in female except for brown patch in lower central region of anepisternum (Colour Plate 4, Fig. 125).

Wing with subcosta completely bare; Radius bare in basal half and with row of 6–11 setae, interspersed with occasional fine hair, in distal half. Costal base tuft as female.

Legs and halteres as in female. Claws long and curved with small, blunt, basal tooth.

Abdominal tergite I yellow with basal fringe of very long, pale and short, dark hairs; tergite II yellow, often with brown mottling at anterior border, and pair of large, submedian pruinose patches; tergite III yellow with brown mottling laterally; tergite IV yellow with pair of large, submedian, dark brown spots, usually not reaching posterior margin; tergite V yellow with pair of small, brown, antero-lateral spots and pair of lateral, silver pruinose patches anterior to these; tergite VI

yellow with pair of submedian, silver pruinose patches towards anterior margin; tergites VII–VIII yellow with large central, dark brown spot, and pair of submedian, silver pruinose patches; tergite IX yellow with silver pruinosity. Tergal plates poorly developed. Sternites and genitalia yellowish. Gonocoxite roughly square; gonostyle subrectangular, twice as long as wide and about two thirds as long as gonostyle, widest at distal margin and small distal spine (more developed in population from R. Patineri (Oyapock)) (Fig. 141). Ventral plate wrinkled with short, thin, sclerotised arms tapering to point; keel slightly developed with long, fine hairs prominent on apex, hairs on rest of keel smaller and stouter (Fig. 153). Median sclerite large, fairly well sclerotised and goblet-shaped with basal stem; distal edge irregular with slight apical incision (Fig. 164). Paramere with many spines varying slightly in size and evenly distributed on posterior half, 5–7 spines slightly more prominent than rest (Fig. 175).

PUPA. Cocoon length dorsally 1.8–2.6 mm ($\bar{x}$=2.1 mm, s.d.=0.2, n=27); ventrally 1.6–2.9 mm ($\bar{x}$=2.3 mm, s.d.=0.3, n=23); pupa length 1.6–2.5 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=25); gill length 0.8–1.6 mm ($\bar{x}$=1.3 mm, s.d.=0.2, n=24).

Cocoon slipper-shaped, pale to mid brown; rim slightly darker and reinforced in central region and without central protuberance (Fig. 186). Cocoon loosely woven, with individual fibres easily visible; sides often slightly flared. Gill light brown with eight forwardly directed, slender filaments arising in basal region; branches intially lie in vertical plane but more distally lie in horizontal plane (Fig. 204). Main trunk giving rise initially to three primary branches, dorsal bifurcating almost immediately and then again to form three filaments, median bifurcating in basal 1/8 and dorsal filament of these again in basal 1/4 to 1/3, ventral bifurcating in basal 1/6. All filaments rounded distally, lightly crenated with their surfaces covered in spicules. Head with 2 + 2 small, simple, frontal and 1 + 1 small, simple, facial trichomes; surface of head with numerous platelets extending over all surfaces, with those on frontal area larger. Thorax with 5 + 5 simple or rarely bifid, antero-dorsal trichomes, one smaller than rest; 2 + 2 weak, simple trichomes towards ventral margin beneath gill base; 1 + 1 small, simple or bifid trichomes in central region of thorax. Numerous platelets occurring over entire thoracic area, larger in anterior region. Abdominal tergite I with 1 + 1 weak, simple hairs towards lateral margins of anterior border; tergite II with 3–4 + 3–4 coarse, simple hairs in row along central region of segment (outer one being much weaker than others) and with 3 + 3 weaker hairs in triangular arrangement on far side of main row; tergites III–IV with 4 + 4 simple hooks on posterior border of segment, 1 + 1 fine, simple hairs anterior to outermost two hooks; tergite V bare; tergite VI with or without 1 + 1 submedian groups of spine combs anteriorly; tergite VII with anterior row of few, weak, submedian spines and 1+1 small patches of spine combs at lateral margin; tergite VIII with anterior row of stronger spines usually stretching across tergite; tergite IX with 1 + 1 small, rounded, dark apical spines and strong patch of submedian spines and spine combs towards antero-lateral margin, often linked by weak row of spines and spine combs. Abdominal sternite III with central patch of weak spine combs; sternite IV with 2 + 2 submedian, simple hairs (outer hair more developed than inner but rarely developed as hook) and spine combs anterior to these and stretching across sternite; sternite V with 2 + 2 simple, bifid or trifid hooks (only inner hook ever trifid) and 1 + 1 anterior areas of spine combs anterior to hooks; sternite VI with four evenly-spaced hooks, inner two bifid or trifid and outer two simple, and 1+1 lateral areas of spine combs anterior to inner hooks; sternite VII with four evenly-spaced hooks, inner two bifid and outer two simple and 1+1 anterior areas of spine combs between outer two; sternite VIII with 1+1 submedian areas of spine combs towards lateral margins, connected by thin line of spine combs towards anterior margin; sternite XI with row of small teeth at anterior margin.

MATURE LARVA. Body length 3.2–4.1 mm ($\bar{x}$=3.7 mm, s.d.=0.2, n=13); width of head capsule 0.3–0.5 mm ($\bar{x}$=0.4 mm, s.d.<0.1, n=13); length of head capsule 0.4–0.5 mm ($\bar{x}$=0.5 mm, s.d.<0.1, n=13).

Body colour pale without prominent banding in alcohol preserved specimens (Fig. 219). Body form as in Fig. 219.

Head yellow with brown markings; occasional setae on head capsule. Head pattern negative (Fig. 232). Postgenal cleft large, as long as wide at maximum width and with pointed anterior margin; postgenal bridge wide, about equal in depth to hypostomium (Fig. 244). Hypostomium (Fig. 255) with strongly pigmented anterior margin and nine blunt apical teeth: corner teeth largest and most prominent; median and sublateral teeth comparatively less developed, but larger than remaining subequal teeth; 4–5 lateral serrations with hindmost about level with first hypostomial seta; 1 + 1 group of four hypostomial setae lying parallel to lateral margins of hypostomium, lowest being much weaker than rest; surface of hypostomium with 1 + 1 short setae towards centre of posterior margin of hypostomium. Antennae long, pale brown with segment ratios approximately 11:11:16. Mandible with first three comb teeth decreasing in size posteriorly and two mandibular serrations of which the anterior is larger. Maxillary palp about two and a half times as long as breadth at base. Cephalic fan with 31–39 rays (n=5).

Thorax mainly white without prominent coloration.

Cuticle mainly glabrous with occasional seta dorsally. Proleg (see Fig. 15) long and slender with lightly sclerotised plate and 22–30 processes. Pupal respiratory histoblast mid brown and claviform.

Abdomen white without obvious banding. Ventral papillae small. Cuticle mainly glabrous with few hairs on dorsum. Anal sclerite mainly sclerotised around anterior arms except basally; posterior arms extend to twelfth row of posterior circlet hooks. Posterior circlet with 67–69 rows of 2–12 hooks (n=3). Anal gill trilobed, each lobe with 2–6 lobules; three main lobes only slightly larger than their lobules.

Taxonomic discussion

The main diagnostic features of females (coloration, wing venation, cibarium, genital fork, paraproct) and pupae (gill configuration, pupal pelt onchotaxy) and other morphological features of the holotype female and pupal pelt of *S. samboni* and *S. santaelenae* collected in Brazil 20km south of the latters' type locality were compared by Shelley *et al.* (1984). These authors placed the latter species in synonymy with *S. samboni*. While this paper was in press, Ramírez Pérez (1983) synonymised *S. santaelenae* with *S. sucamense* Nunes de Mello, 1974 and this action was followed by Ramírez Pérez (1987) and Crosskey (1988) who both maintained *S. samboni* as a valid species. Py-Daniel (1989) agreed with the synonymy of these two former authors and further synonymised *S. sucamense* with *S. iracouboense* Floch & Abonnenc with no explanation. Coscarón (1985) supported the synonymy of *S. santaelenae* with *S. samboni* of Shelley *et al.* (1984).

We have now examined all stages of '*sucamense*' from the R. Surumu, Brazil close to the type locality and '*santalenae*' from a site 20kms south of its type locality in Venezuela and the female lectotype (No 755) and male paralectotype (No 756) of *S. iracouboense* and compared this to reared males and females from the type locality at Cafesoca, R. Oyapock. The two type specimens were removed from mature pupae and so body coloration is difficult to see beyond the overall orange coloration. However, the lectotype female cibarium, genital fork, paraproct, legs and nudiocular triangle are identical to the reared material; in the paralectotype male the abdominal coloration and genitalia are identical to topotypes; in the male and female pupae gill configuration, onchotaxy and platelet distribution was identical in the two type specimens and topotypes. Therefore, we accept our new material as conspecific with *S. iracouboense* and accept *S. sucamense* and *S. santaelenae* as conspecific and therefore junior synonyms. A comparison of all stages of *S. iracouboense* with *S. samboni* from its type locality showed the following differences. In *S. samboni*, the female has approximately the same dimensions as *S. iracouboense* (body length 1.7–2.1 mm, $\bar{x}$=1.9 mm, s.d.=0.2, n=3, wing length 1.9–2.0 mm, n=2, wing width 0.8–1.1 mm, n=2), but is darker orange in colour and the basal section of the Radius in the female is more densely haired; in the male (body length 2.0–2.4 mm, $\bar{x}$=2.2 mm, s.d.=0.1, n=7, wing length 1.5–1.9 mm, $\bar{x}$=1.7 mm, s.d.=0.1, n=6, wing width 0.6–1.0 mm, $\bar{x}$=0.8 mm, s.d.=0.1, n=6) the gonostyle is small, slightly longer than wide subtriangular, less than half length of gonocoxite and with smaller terminal spine (Fig. 142); the pupa is larger: cocoon length dorsally 2.3–3.1 mm ($\bar{x}$=2.6 mm, s.d.=0.2, n=34); ventrally 2.3–3.3 mm ($\bar{x}$=2.7 mm, s.d.=0.4, n=35); pupa length 1.5–2.7 mm ($\bar{x}$=2.2 mm, s.d.=0.3, n=33); gill length 1.5–3.1 mm ($\bar{x}$=2.3 mm, s.d.=0.3, n=33), the cocoon is of a closer mesh, branching of filaments is significantly more distal (Fig. 205), the 2+2 frontal and 1+1 facial trichomes are well developed and bifid or trifid, the 5+5 anterodorsal trichomes are all bifid or trifid; abdominal tergite V with row of 5+5 weak hairs, tergites VI–IX with row of 1+1 strong spines, sternite IV with 1+1 simple or bifid hooks and 1+1 weak hairs. Minor differences in larvae are in dimensions (body length 3.3–4.4 mm, $\bar{x}$=4.1 mm, s.d.=0.3, n=19; width of head capsule 0.4–0.7 mm, x–=0.5 mm, s.d.=0.1, n=19, length of head capsule 0.5–0.7 mm, $\bar{x}$=0.6 mm, s.d.=<0.1. n=19) and larger ventral papillae. Examination of chromosomal standard micrographs of karyotypes of *S. samboni* from Panama and *S. sucamense* from Brazil in the BMNH collection prepared by Dr W.S.Procunier have shown inversion polymorphism differences, but it is not clear whether these are interspecific, examination of more specimens from other populations being necessary before species status may be decided (personal communication, M.Charalambous).

Simulium iracouboense is regarded as a member of the subgenus *Psilopelmia* as indicated by Crosskey (1988), who also included *S. samboni* and *S. sucamense*. Py-Daniel (1989) also placed *S. samboni* and *S. iracouboense* in this subgenus, but Coscarón, (1985) placed *S. sucamense* in *Ectemnaspis* and *S. santalenae* in *Psilopelmia*. In 1987 he maintained *S. sucamense* in *Ectemnaspis* and placed *S. samboni* and *S. iracouboense* in *Psilopelmia* but in 1990 moved *S. sucamense* to *Psilopelmia*.

Distribution

This species was only found in rapids on large rivers in lowland localities (Catrimani, Mucajai) of the Brazil focus (Table 1). In the Venezuelan part of the focus (Table 2) it was collected in similar conditions at Peñascal and the headwaters of the R. Caura in southern Bolivar State, Venezuela.

It also occurs in rapids on large rivers outside the focus in the states of Roraima, Pará and Amapa in

Brazil as well as in French Guiana and Surinam (Material Examined). In Venezuela it is found in rivers on the southern Guayana shield (Ramírez Pérez, 1983).

Simulium (Psilopelmia) lutzianum Pinto

(Colour Plate 2, Fig. 32; Colour Plate 4, Fig. 126; Figs 43, 54, 65, 76, 87, 98, 109, 143, 154, 165, 176, 187, 206, 220, 233, 245, 256)

Simulium lutzianum Pinto, 1932: 748. LECTOTYPE ♀, VENEZUELA: Aragua State, Maracay, Rio Limon, 1925 (*A.Lutz & Továr, N.*) (IOC). [Here designated.]

Simulium lewisi Ramírez Pérez, 1971: 349. HOLOTYPE ♀, VENEZUELA: Miranda State, Panaquire, [No collection date]; (collector presumably *J. Ramírez Pérez* or *D.J.Lewis*) (DERM). **New synonymy**

Simulium iguazuense Coscarón 1976: 147. HOLOTYPE ♀ ARGENTINA: Parque Nacional Iguazu, route 101, in unnamed stream, 17.x.1974 (*S. Coscarón*) (MLP). [Synonymised with *S. lewisi* by Coscarón, 1985: 304.] **New synonymy**

Only low numbers of specimens were collected in the focus (see material examined)-variations in dimensions and morphology are largely based on material from Ecuador. Measured Brazilian specimens are from Auaris.

FEMALE. General body colour orange and black. Ecuador specimens: body length 1.6–2.5 mm ($\bar{x}$=2.0 mm, s.d.=0.25, n=11) (Auaris 2.2 mm, n=1); wing length 1.8–2.2 mm ($\bar{x}$=1.9 mm, s.d.=0.12, n=13) (Auaris, 2.0 mm, n=1); wing width 0.8–0.9 mm ($\bar{x}$=0.9 mm, s.d.=0.04, n=12) (Auaris 0.9 mm, n=1).

Head dichoptic with dark red eyes; nudiocular area poorly developed (Fig. 43). Frons, clypeus and occiput black with silver pruinosity. Mouthparts mid brown, maxillary palps dark brown. Cibarium with five irregular rows of blunt tubercles in area of central trough and group of about 20–30 minute teeth between this and each cornua; anterior margin of cibarium sclerotised (Fig. 54).

Scutum orange, humeri yellow to light orange, lateral scutal margins yellowish orange with brilliant white pruinosity. Paranotal folds dark brown with silver pruinosity. Scutum with numerous adpressed dark brown hairs lying singly. Pleural region mainly dark brown with faint silver pruinosity although in some specimens orange to light brown patches may occur in the area adjacent to the paranotal folds. Scutellum orange with erect brown hairs on posterior margin. Postnotum dark brown with faint silver pruinosity (Colour Plate 2, Fig. 32).

Subcostal wing vein usually with 1–6 setae in median third of the vein, in some cases without setae; basal section of Radius with single row of setae to base of vein (Fig. 65). Costal base tuft of dark brown setae.

Legs black except basal two-thirds of mid and hind basitarsi, which are white (Colour Plate 2, Fig. 32). Tarsi narrow as in *S. exiguum* (Fig. 2). Claws curved, each with small tooth as in Fig. 76. Halteres yellow with light brown stems.

Abdominal tergites I–III bright yellow, sometimes orange, tergite IV velvet-black, tergites VI–IX shiny black or mottled brown and black (Colour Plate 2, Fig. 32). Occasionally specimens occur in which tergites I–IV are yellow, in which case tergite V is velvet-black. Tergal plates (Fig. 5) well developed on segments IV–IX. Sternites I–III yellowish brown, rest mid brown, genitalia dark brown. Eighth sternite well sclerotised with about 15–18 setae on each side; gonopophyses small, membranous with minute hairs (Fig. 87). Cerci hemispherical; paraprocts with pronounced ventral extension (Fig. 98). Genital fork slender with sclerotised, triangular anteriorly-directed processes (Fig. 109). Spermatheca similar to that of *S. exiguum* (Fig. 6), oval, sclerotised, with no external sculpturing and randomly distributed spicules on internal surface. Area of insertion of spermathecal duct membranous, one-third as wide as maximum width of spermatheca.

MALE. General body colour orange and black. Ecuador: body length 1.7–3.1 mm ($\bar{x}$=2.2 mm, s.d.=0.35, n=16) (Auaris 2.0 mm, n=1), wing length 1.7–2.0 mm ($\bar{x}$=1.8 mm, s.d.=0.1, n=19) (Auaris 1.8 mm, n=1), wing width 0.7–0.9 mm ($\bar{x}$=0.9 mm, s.d.=0.06, n=16) (Auaris 0.9 mm, n=1).

Head holoptic with dark red eyes. Coloration of rest of head as in female.

Coloration and hairing of thorax and its appendages as in female (Colour Plate 4, Fig. 126) except subcostal vein of wing devoid of setae. Morphology of legs as in Colour Plate 4, Fig. 126.

Abdominal tergites I–III yellow, rest of tergites and genitalia velvet-black; basal fringe of long black hairs. Silver ornamentation on tergites as follows: tergite II faintly silver pruinose and tergites VI, VII and IX with obvious silver patches laterally (Colour Plate 4, Fig. 126). Sternites I–III orange, IV–IX dark brown with well developed sternal plates on segments IV–VIII. Gonocoxite longer than wide, gonostyle with distal spine longer than wide and about half length of gonostyle (Fig. 143). Ventral plate membranous with lightly sclerotised, reduced basal arms, a small keel and hairs covering most of its surface (Fig. 154). Median sclerite pyriform with small apical incision (Fig. 165). Paramere as in Fig. 176 with few distal spines of varying sizes.

PUPA. Ecuador: cocoon length dorsally 2.2–2.7 mm ($\bar{x}$=2.5 mm, s.d.=0.14, n=20), ventrally 2.1–2.8 mm ($\bar{x}$=2.5 mm, s.d.=0.16, n=20); pupa length 1.8–2.6 mm ($\bar{x}$=2.2 mm, s.d.=0.22, n=20); gill length 1.8–2.8 mm

($\bar{x}$=2.3 mm, s.d.=0.31, n=30) (Auaris 2.3 mm, n=1).

Cocoon slipper-shaped, white under natural conditions and light brown in alcohol; rim of aperture thickened and without median protuberance, median thickened dorsal ridge connecting with rim of aperture (Fig. 187). Cocoon very thick, composed of amorphous elastic substance containing fibres which are only apparent under higher magnification. Gill light brown with eight forwardly directed slender filaments arranged in a vertical plane (Fig. 206). Main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments. Ventral branch bifurcation at limit of basal 1/3 of total gill length, first division of median and dorsal branches arise in same region but individual specimens vary in the exact position (some showing divisions at the same distance from the gill base in all three branches while in others these divisions occur at different points on each branch), the most dorsal of the two filaments arising from this division in the median and dorsal primary branches again bifurcate usually at same level on each branch at mid point of gill; filaments slender with crenate edges, rounded distally, their surfaces covered in spicules. Head with 2+2 frontal trichomes usually with 4–6 branches but sometimes up to eight and 1+1 facial trichomes with 2–4 branches, trichomes well developed; surface of head with few platelets mainly concentrated around facial trichomes. Thorax with 5+5 well developed trichomes with 6–8 branches on anterior margin of thorax. Anterior half of surface of thorax with scattered platelets. Abdominal tergite II with 4+4 simple hairs, III–IV with 4+4 simple hooks, VI–IX with spine combs on anterior margins, tergite IX with 1+1 unbranched spines; sternite IV in both sexes with 1+1 inner simple or bifid hooks and 1+1 outer fine setae, V–VII with 2+2 hooks with 1 to 3 branches; 1+1 patches of spine combs on postero-lateral borders of sternites IV–VIII.

MATURE LARVA. Body length 3.5–4.6 mm ($\bar{x}$=4.1 mm, s.d.=0.24, n=30). Width of head capsule 0.4–0.5 mm ($\bar{x}$=0.5 mm, s.d.=0.02, n=30), length of head capsule 0.4–0.6 mm ($\bar{x}$=0.5 mm, s.d.=0.03, n=30).

Body colour white with either greyish purple or green markings (Fig. 220). These colour variations are not sex linked (W. S. Procunier, pers. comm.). In Carnoy's fixative markings are bright purple or green and more distinct. Body form as in Fig. 220.

Head yellow with scattered minute setae on all surfaces. Head spots generally indistinct being the same colour as the rest of the head capsule, but in some specimens a negative pattern occurs (Fig. 233). Postgenal cleft large, longer than wide, with rounded anterior margin; postgenal bridge short, about one-tenth as long as hypostomium (Fig. 245). Membrane within postgenal cleft containing green or grey chromatocytes that obscure the outline of the cleft. Hypostomium as in (Fig. 256). Antennae long, light brown, with segment ratios 14:13:12. Mandible with second comb tooth shorter than the first or third. Maxillary palp short, about twice as long as width at base. Cephalic fan with 30–34 rays.

Thorax whitish grey with few scattered dark greyish purple spots dorsally and two central greyish purple patches ventrally posterior to the proleg. In some specimens green replaces the grey coloration. Cuticle with scattered small hairs on ventral and lateral surfaces but densely distributed on the dorsum. Proleg plate lightly sclerotised with about twelve processes. Pupal respiratory histoblasts dark brown and ovoid.

Abdomen whitish grey with a prominent dark greyish purple band on first and fourth narrow abdominal segments, posterior (wide segments) of abdomen with four dark greyish-purple bands dorsally that often coalesce and scattered patches of grey pigment laterally and ventrally. Pigment in some specimens green. Ventral papillae absent or very reduced and indistinct. Cuticle with densely distributed minute hairs on dorsum, more scattered laterally and absent ventrally. Anal sclerite well sclerotised with posterior arms extending to the row of posterior circlet hooks. Posterior circlet with 56–60 rows of 4–14 hooks. Anal gill trilobed, median lobe with 6–7 secondary lobules, lateral lobes with 8–11 secondary lobules.

Taxonomic discussion

Simulium lutzianum was collected by Lutz and Nuñez Továr from Aragua State in northern Venezuela in 1925. In 1928 Lutz provided short descriptions of the female, male and pupa under the name *Simulium ochraceum* Walker and the species was reported not to attack man; larvae and pupae were collected in the Rio Limón. Figures of the female and pupa were given but errors in figure numbers caused considerable confusion (Figure 6 of Plate 4 is non existent and reference(s) to the adult female apply to figure 4; figure 3 of plate 6 is of the pupal gill of *S. rubrithorax*, whereas figure 2 is of '*S. ochraceum*', not vice versa as stated in the text and figure index). D'Andretta & d'Andretta (1946) corrected the many errors in Lutz (1928) caused by incorrect association between figures and text and believed that the pupal figure identified by Lutz as *S. rubrithorax* should have been linked to the description of *S. ochraceum*. In his revision of the Simuliidae of Central and South America Pinto (1932) examined syntypes of *S. rubrithorax* described in Lutz (1909) and Lutz's material collected in Venezuela (Lutz, 1928) and concluded that the figure (2 of plate 6) of the *rubrithorax* pupa in the latter paper was not of this species and provisionally named it as *S. lutzianus*. The two photographs of the pupa of *S. lutzianus* were from Lutz's material collected at the Rio Castanho in Venezuela and correspond to '*S. ochraceum*' figured in

Lutz (1928), but no lectotype designation was made. Dampf (1943) redescribed the pupa of *S. ochraceum* Walker from material collected in southern Mexico and confirmed that the '*ochraceum*' of Lutz (1928) from Venezuela was a different species, which he declined to name despite citing *S. lutzianum* of Pinto (1932) as a similar species. Ramírez Pérez (1971) prospected the localities visited by Lutz in 1925 and confirmed that these pupae were of *S. lutzianum* and not *S. ochraceum*. Our examination of type material in IOC revealed the following. No *S. lutzianum* specimens were found in the Pinto collection but a slide of a 'type' pupa of this species on slide number 2720 is recorded in the index as lost. Similarly, the index to the Lutz collection records slide numbers 12.213 and 12.919 of '*S. ochraceum*' from Maracay, 1925 as being lost. However, three tubes of pinned males and females labelled as '*Simulium ochraceum* Walker, Rio Limon, Maracay. 1925. Obtido por criaçao." were found in the Lutz collection. This is obviously part of the original syntype series of Lutz (1928) from which Pinto (1932) described a pupa as *S. lutzianum* and consists of 17 females and 11 males. We have selected a female as lectotype and accordingly labelled the specimen. Abdominal segment coloration was very variable among the syntype series: 8 females had the first abdominal segment orange, 8 females had the first three segments orange and one was without abdomen; one male had the first abdominal segment orange, one had the first two orange, 7 had the first three orange, one had none orange and one was without an abdomen. A slide preparation of a female and another of a male showed the material to be conspecific with that described in this paper.

In their description of *S. lewisi* from Ecuador Shelley *et al.* (1989) discussed the synonymy by Coscarón (1985) of *S. iguazuense* Coscarón and the possibility that these two nominal species may be junior synonyms of *S. lutzianum*. The only morphological differences between these species (Ramírez Pérez, 1971) occurs in the coloration of the abdominal tergites in females and males (female *S. lewisi*-first 3 or 4 segments yellow or orange, female *S. lutzianum*-only first tergite yellow or orange; male *S. lewisi*-first 3 or 4 segments yellow or orange, male *S. lutzianum*-no yellow tergites). The two specimens reared from the R. Auaris were a female with 3 orange tergites and a male with no orange tergites i.e. a female *lewisi* and a male *lutzianum* using the interspecific characters of Ramírez Pérez (1971). Recent studies by Sawyer (1991) in Ecuador on *S. lewisi* and *S. lutzianum* used morphology, isoenzymes, larval polytene chromosomes and adult hydrocarbons in an attempt to resolve the problem. Her findings showed that three cytotypes (A,B,C) occurred that did not correspond to the distribution of *S. lewisi* and *S. lutzianum* based on these morphological characters and that hydrocarbon profiles correlated more significantly to cytotype than to morphospecies distributions. She concluded that a *lewisi-lutzianum* complex existed and that colour polymorphism may not be cytospecies linked. These findings agree with the colour variation seen in the type series of *S. lutzianum*. Based on this evidence we synonymise *S. lewisi* with *S. lutzianum* and regard cytotypes A,B and C as belonging to the *S. lutzianum* species complex. Other closely related species that may belong to this complex are *S. alirioi* Ramírez Pérez & Vulcano, *S. gabaldoni* Ramírez Pérez, *S. romanai* Wygodzinsky and *S. adolfolutzi* Wygodzinsky.

Coscarón (1987,1990,1991) placed *S. lutzianum* in the subgenus *Ectemnaspis*, whereas Crosskey (1988) maintained it as *Psilopelmia*.

Distribution

Simulium lutzianum was only collected from the R. Auaris on one occasion and was found at ParimaA and B on the Venezuelan side of the focus (Tables 1 & 2). It has a wide distribution outside the focus.

In Ecuador it is a common species of the onchocerciasis foci and circumjacent lowland areas on the eastern and western foothills of the Andean cordillera. It is widespread in northern Venezuela (Ramírez Pérez, 1983). Coscarón (1985, 1991) reported this species from Argentina, Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela and it also occurs in Panama (Material Examined).

Simulium (Psilopelmia) rorotaense Floch and Abonnenc

(Colour Plate 2, Fig. 33; Colour Plate 4, Fig. 127; Figs 44, 55, 66, 77, 88, 99, 110, 144, 155, 166, 177, 188, 207, 221, 234, 235, 246, 257)

Simulium rorotaense Floch & Abonnenc, 1946b: 4. LECTOTYPE♀ and associated pupal pelt, FRENCH GUIANA: Rorota Plateau, vi.1945 (*Floch & Abonnenc*) (IP) by designation of Shelley *et al.* (1984: 153).

Simulium maroniense Floch & Abonnenc, 1946b: 9. LECTOTYPE ♀, FRENCH GUIANA: Sinnamary, Coeur Maroni Creek, iii.1945 (no collector) (IP) by designation of Shelley *et al.* (1984: 153). [Synonymy by Shelley *et al.*, 1984: 153.]

Simulium marionense Ortiz, 1957: 166. [Incorrect subsequent spelling of *S. maroniense* Floch & Abonnenc.]

Simulium wuayaraka Ortiz, 1957: 163. HOLOTYPE ♀, [incorrectly cited as allotype], VENEZUELA: Bolivar State, Auyantepuy, Rio Guayaraca (no collection date) (*J.V. Scorza*) (ESUCV). [Synonymy by Shelley *et al.*, 1984: 153.]

Simulium wayaraka Vulcano, 1967: 44. [Incorrect subsequent spelling of *S. wuayaraka* Ortiz.]

Simulium wuayaraca Ramírez Pérez, Yarzábal & Peterson, 1982: 96. [Incorrect subsequent spelling of *S. wuayaraka* Ortiz.]

Simulium fulvinotum Cerqueira & Nunes de Mello in Cerqueira, 1967: 136. LECTOTYPE ♀ and associated pupal pelt [incorrectly cited as holotype by Cerqueira & Nunes de Mello, 1968], BRAZIL: Manaus, Cachoeira Alta, Igarapé do Tarumã, 27.IV.1961 (*N.L.Cerqueira & J.A.S.Nunes de Mello*) (INPA). [Synonymy by Py-Daniel, 1982: 306]

Simulium ignacioi Ramírez Pérez & Vulcano, 1973: 387. SYNTYPES ♂, ♀ and eight pupae, VENEZUELA: Bolivar State, Cabanayen (Gran Sabana) (no collection date, collector's name or depository). [Synonymy by Ramírez Pérez, 1983: 8.]

FEMALE. General body colour orange. Body length 3.1–2.1 mm ($\bar{x}$=2.5 mm, s.d.=0.4, n=10); wing length 1.8–2.6 mm ($\bar{x}$=2.3 mm, s.d.=0.3, n=10), wing width 0.9–1.2 mm ($\bar{x}$=1.1 mm, s.d.=0.1, n=7).

Head dichoptic with eyes dark red (appearing black in dried specimens); nudiocular area fairly well developed (Fig. 44). Frons, clypeus and occiput black with silver pruinosity. Mouthparts dark brown. Antennae with basal quarter bright yellow/orange and remainder brown with heavy pruinosity. Cibarium without central trough; heavily sclerotised at margin and on cornuae. 1+1 groups 9–12 large teeth either side of central trough (teeth not extending onto cornuae) (Fig. 55). Numerous densely packed, coarse, spiny teeth in central membrane anterior to trough.

Scutum orange with occasional dark brownish/black flecks (particularly near anterior and posterior margins) (Colour Plate 2, Fig. 33). Scutum with numerous, adpressed, golden setae; some darker setae in anterior region. Humeri yellow with dark brown margins; and with narrow bands of silver pruinosity on lateral margins above paranotal folds. Scutellum orange/yellow and covered with adpressed, golden setae and long, upright, dark hairs along posterior margin. Postnotum orange with dark brown pruinose patches on anterior margin, sometimes extending over entire surface. Paranotal folds dark brown with silver pruinosity. Pleural region dirty yellow/orange often with dark brown patches and silver pruinosity.

Subcostal vein with 7–11 setae in basal 3/5 (majority of these situated in central region) (Fig. 66). Radius with single row of 31–50 hairs along entire length. Costal base tuft dark brown. Halteres pale yellow with pale brown stems.

Leg coloration showing considerable variation. Fore leg with coxa, trochanter and femur yellow; tibia varying from mid brown with distal tip dark, to entirely dark brown; all tarsi dark brown. Mid leg with coxa yellow to mid brown; trochanter and femur yellow; tibia usually pale brown but sometimes darker, notably distal quarter; basal three quarters of basitarsus and basal two thirds of second tarsomere yellow, remaining areas dark brown; remaining tarsi dark brown. Hind leg with coxa mid to dark brown; trochanter yellow; femur usually completely yellow though occasionally distal tip is brown; tibia mid brown sometimes with distal quarter dark brown; basal three quarters of basitarsus yellow/white, remainder dark brown; remaining tarsi dark brown. Tarsi narrow as in *S. exiguum* (Fig. 2). All femora and tibiae with coarse dark hairs; scales present as in *S. exiguum* (Fig. 4). Claws curved with prominent sub-basal tooth (Fig. 77).

Abdominal tergite I pale, dirty yellow with grey/black posterior margin and light pruinosity; fringe of small, fine, dark and golden hairs. Tergites II and III yellow/orange with posterior margin grey/black pruinose. Remaining tergites shiny black with amorphous, orange mottled patches, predominantly at anterior margin. Tergal plates well developed. Sternites dirty yellow to dark brown. Genitalia dark brown. Eighth sternite well sclerotised with 1+1 groups of 10–13 large and 5–7 small hairs, gonopophyses brown, relatively large, membranous, lightly sclerotised (Fig. 88). Cerci hemispherical, paraprocts large, at least twice as long as wide, narrowing distally with several prominent central spines and numerous, coarse setae towards outer margin and tip (Fig. 99). Genital fork with relatively short, sclerotised stem and spatulate end; lateral arms well developed with rounded triangular anterior processes (Fig. 110). Spermatheca oval, sclerotised without external sculpturing; spicules of inner surface arranged roughly in rings; width of membranous area small, about quarter maximum width of spermatheca.

MALE. General body colour orange. Body length 1.9–3.6 mm ($\bar{x}$=2.9 mm, s.d.=0.4, n=16); wing length 1.8–2.6 mm ($\bar{x}$=2.3 mm, s.d.=0.2, n=12); wing width 0.8–1.2 mm ($\bar{x}$=1.0 mm, s.d.=0.1, n=11).

Head holoptic with upper eye facets red, lower ones darker red (appearing black in dried specimens). Remaining head coloration as in female.

Thoracic coloration as in female, coloration generally darker (Colour Plate 4, Fig. 127). Pruinosity on humeri and lateral margins less prominent than in female, postnotum nearly always with dark pruinose patches covering entire area, only extreme margin orange.

Subcostal vein bare, sometimes with 2–3 fine setae. Radius with single row of 35–50 hairs along entire length; some coarse setae laterally. Costal base tuft dark brown. Halteres yellow with orange/brown stems.

Leg coloration very variable. Fore leg with coxa, trochanter and femur yellow or mid brown; remaining areas dark brown. Mid leg with coxa dark brown; trochanter ranging from yellow to mid brown; femur yellow; tibia mid to dark brown; basal three quarters of

basitarsus yellow, remainder dark brown; remaining tarsi dark brown. Hind leg with coxa dark brown; trochanter pale to dark brown; femur and tibia varying from mid to dark brown (tibia often darker than femur except for basal tip which is often pale); basal two thirds of basitarsus white, remainder dark brown; remaining tarsi dark brown. All femora and tibiae with coarse dark hairs and scale-like hairs. Claws curved and slender, lacking basal tooth.

Abdominal tergite I dirty yellow/orange except velvet brown posterior border; fringe of long, fine, dark hairs. Tergite II dirty, pale yellow with mottled brown/orange posterior margin, pair of large, lateral, pruinose silver patches. Tergites III–IV velvet black with slight orange mottling at anterior border; pair of small, silver, pruinose patches towards anterior margin. Tergites V–VI velvet black and slightly mottled orange; pair of large, lateral, silver pruinose patches. Tergites VII–VIII velvet black with pair of smaller, postero-lateral, silver pruinose patches; (patch on VII larger than that on VIII). Tergite IX velvet black, lightly pruinose. Tergal plates poorly developed. Sternites grey/yellow. Genitalia dark brown. Gonocoxite large and approximately square; gonostyle large, slightly longer than length of gonocoxite and at maximum half its width, curved inwards and with small, apical spine (Fig. 144). Ventral plate with large, prominent, elongated keel at approximate right angle to basal arms, giving mid area of ventral plate thick appearance; basal arms short and highly sclerotised; long fine hairs restricted to keel with shorter, thicker hairs on remainder of plate (Fig. 155). Median sclerite arrow-shaped distally and short shaft (Fig. 166). Paramere with several short, blunt teeth along its length, lacking any prominent teeth (Fig. 177).

PUPA. Cocoon length dorsally 2.4–3.5 mm ($\bar{x}$=3.0 mm, s.d.=0.3, n=22); ventrally 3.0–4.2 mm ($\bar{x}$=3.6 mm, s.d.=0.4, n=22); pupa length 1.7–3.2 mm ($\bar{x}$=2.6 mm, s.d.=0.4, n=22); gill length 1.2–1.8 mm ($\bar{x}$=1.5 mm, s.d.=0.2, n=17).

Cocoon slightly shoe-shaped with festoons on anterior margin often forming large space on each side of cocoon (Fig. 188). Cocoon composed of thick, coarse fibres giving a loose, open weave. Gill light brown with 18–20 relatively short, fine filaments radiating out in form of fan (Fig. 207) slightly protruding from anterior aperture of cocoon. Main trunk short and stout, giving rise to two thick primary branches from which filaments arise in pairs or singly with bifurcations in basal 1/6 of gill; dorsal with 10 filaments pointing dorsally and laterally away from head and ventral with 8 filaments directed downwards over head. Filaments with crenate margins and rounded distally, their surfaces covered in spicules giving appearance of rings. Frontoclypeus with some variation in the number of frontal trichomes, either 2 + 2 or 3 + 3 well developed 3–7 branched and 1 + 1 well developed facial trichomes with 3–6 branches; frontal surface covered with large and small rounded platelets. Thorax with 5 + 5 well developed antero-dorsal trichomes with 3–6 branches; 1 + 1 submedian, bifid trichomes in central region; 1 + 1 simple hairs in area below gill base. Surface of anterior half of thorax densely covered in large round platelets, posterior half covered in much smaller, less distinct platelets. Abdominal tergite I lightly sclerotised with some scattered setae, 1–2 + 1–2 of which are stronger, and occasionally bifid. Tergite II with 6–7 + 6–7 hairs in approximate row, inner 3–4 hairs coarse, outer three hairs finer and slightly segregated; 1 + 1 antero-lateral groups of fine combs (often absent). Tergites III–IV with 4 + 4 simple hooks towards posterior margin, small hair above and between outer two, and several hairs at lateral margin. Tergite V with 5 + 5 weak hairs in approximate line centrally and with first hair separated from the rest. Tergites VI–IX with few scattered setae and 1 + 1 patches of antero-lateral spine combs. Sternite III with median patch of spine combs towards anterior border and scattered setae. Sternite IV with median patch of spine combs extending over much of sternite and 2–3 + 2–3 strong hairs. Sternite V with 2 + 2 bifid or trifid hooks towards posterior margin and 1 + 1 patches of spine combs above hooks. Sternite VI with 4 bifid or trifid hooks towards posterior margin, 1 + 1 patches of spine combs above and between outer two hooks and several scattered hairs. Sternite VII with 3–4 simple or bifid hooks and 1 + 1 anterior patches of spine combs (anterior to outer two hooks). Sternite VIII with 1 + 1 posterior patches of small spines. Sternite IX with 1 + 1 patches of small, fine, rounded, sub-apical spines.

MATURE LARVA. Body length 2.2–6.4 mm ($\bar{x}$=4.9 mm, s.d.=1.3, n=11); width of head capsule 1.2–1.5 mm ($\bar{x}$=1.4 mm, s.d.=0.1, n=11); length of head capsule 1.4–1.8 mm ($\bar{x}$=1.7 mm, s.d.=0.1, n=11). Body colour dirty white with grey markings (Fig. 221).

Head yellow to mid brown with some scattered setae. Head pattern usually positive but not prominently (Fig. 234); more rarely head pattern negative (Fig. 235). Postgenal cleft deep, longer than wide, constricted at base then widening slightly and forming a point anteriorly. Postgenal bridge narrow, being about one third to half width of hypostomium (Fig. 246). Hypostomium with pigmented anterior margin and nine apical teeth: corner teeth large with double crown; median tooth pointed and slightly less developed; second teeth also obvious; remaining intermediate teeth smaller and indistinct; 5–7 sharp, lateral serrations; 1 + 1 groups of 5–7 hypostomial setae lying parallel to lateral margins of hypostomium the latter 1–2 being less well developed; surface of hypostomium with few, short setae (Fig. 257). Antennae relatively short with basal and third segments

clearly pigmented, segment ratios approximately 1:1:1. Mandible with first three comb teeth stout and decreasing in size; two very well defined mandibular serrations of which anterior is larger. Maxillary palp approximately 2½ times as long as wide at base. Cephalic fan with 28–38 rays (n=6).

Thorax dirty white with large amorphous grey area directly beneath proleg and grey patch lying anterior to histoblast. Cuticle with few scattered setae. Proleg (see Fig. 15) with plates well sclerotised with 12–14 bifid or trifid processes. Pupal respiratory histoblast dark brown and claviform.

Abdomen usually dirty white anteriorly with dorsolateral grey patches on all segments often forming bands and progressively occupying a greater area. Ventral papillae absent. Cuticle with few scattered setae. Anal sclerite well sclerotised; anterior arms considerably shorter than posterior arms. Area above and lateral to posterior arms with well spaced, coarse setae. Posterior arms extending at least to row 17 of posterior circlet hooks. Posterior circlet with 90–94 rows of 2–15 hooks. Anal gill trilobed, each lobe with 9–16 long, finger-like lobules.

Taxonomic discussion

The taxonomic status of the type material used in the original description of *S. rorotaense* by Floch & Abonnenc (1946b) and the synonymies given above were discussed by Shelley *et al.* (1984). Since then we have examined two reared males and pupal pelts labelled as *S. wuayaraka* from Sierra de Parima and *S. ignacioi* from Wonaven, Bolivar State, deposited in the BMNH by Dr Ramírez Pérez and we maintain all of the synonymies cited in our previous paper. Crosskey (1988) accepted these synonymies in his checklist of blackflies of the world but some recent publications have not accepted it in its entirety. Ramírez Pérez (1983) regarded *S. wuayaraka* as a synonym of *S. maroniense* and distinct from *S. rorotaense*. The original description of *S. wuayaraka* (Ortiz, 1957) was based on man-biting females collected by Dr J.V.Scorza near the headwaters of the R. Guayaraca in the region of Auyantepuy in Bolivar State, Venezuela. Examination of pupae and reared adults collected in the Sierra de Parima and the description of Ortiz led Ramírez Pérez (1983) to the conclusion that *S. wuayaraka* was a synonym of *S. maroniense* from French Guiana. Figures of the morphology of pupa and adults of *S. maroniense* given by the latter author and the reared male and pupal pelt from the Sierra de Parima in the BMNH collection exactly correspond to type material of *S. maroniense* and *S. rorotaense*. However, Ramírez Pérez (1983) maintained *S. maroniense* and *S. rorotaense* as separate species and synonymised *S. ignacioi* with the latter without explaining this action. The figures for *S. ignacioi* published in Ramírez Pérez *et al.* (1982) were then used to illustrate *S. rorotaense* in the subsequent publication (Ramírez Pérez, 1983). Unfortunately the figure of the male scutum shows the presence of submedian comma-shaped marks on the anterior and posterior borders, neither of which are mentioned in the original descriptions of *S. rorotaense* (Floch & Abonnenc, 1946b) or *S. ignacioi* (Ramírez Pérez & Vulcano, 1973). Also the pupal gill illustrated by Ramírez Pérez *et al.* (1982) for *S. ignacioi* and Ramírez Pérez (1983) for *S. rorotaense* shows a different arrangement of filaments from that seen in the actual *S. rorotaense* and it is possible that *S. suarezi* was being confused with this material.

In a review of the subgenus *Ectemnaspis*, Coscarón (1985) commented on the similarity of *S. rorotaense, maroniense* and *wuayaraka* but maintained them as individual species based on their original descriptions. Later (Coscarón, 1987), accepted without comment the synonymy for *S. rorotaense* given in Shelley *et al.* (1984) with the exception of *S. wuayaraka*. This was placed in his subgroup *dinellii*, which he separated from *S. rorotaense* in the subgroup *perflavum* on the basis of differences in the cibarial morphology of females. However Ortiz' figure (1957) of the cibarium of *S. wuayaraka* entirely corresponds with that of *S. rorotaense*. In 1990 Coscarón accepted the synonymies of Shelley *et al.* (1984), but believed *S. maroniense* to be distinct because of minor differences in the sensory organ of the female maxillary palp, length of pupal gill filaments, trichomes and platelets; he believed similarly that *S. wuayaraka* was distinct, based on cibarial morphology. This was followed by Coscarón in 1991, but *S. ignacioi* was not included. The character used in the key for separating female *S. rorotaense* and *S. maroniense* from *S. wuayaraka* was that of the cibarial armature used also in his 1985 paper, and *S. rorotaense* was separated from *S. maroniense* using the length of the sensory organ in the female maxillary palp. Male *S. rorotaense* and *S. maroniense* cannot be separated and the male *S. wuayaraka* is not included in the key. Pupae of the two former species are distinguished from one another by gill filament length and trichome size and number of branches, with again no mention of *S. wuayaraka*.

Simulium rorotaense closely resembles *S. suarezi*, the pupa and female of which are described from Venezuela by Ramírez Pérez *et al.* (1977). The two species are distinguished on pupal gill configuration and the pair of submedian yellow comma-shaped marks in the male *S. suarezi*. *Simulium panamense* (described in Fairchild, 1940) can be distinguished most easily from *S. rorotaense* in the female by the presence of two submedian white vittae on the thorax, the absence of hair-like teeth on the central trough of the cibarium and the longer and distally thinner paraproct; in the male by the presence of a pair of submedian white comma-shaped marks running from the anterior bor-

der of the scutum along one half of its length and by the subrectangular gonostyle; in the pupa by the absence of anterior festoons and a non-reticulated surface to the cocoon and the configuration of the pupal gill, the filaments of which are bunched together; in the larva all segments of the antenna are pigmented, the postgenal cleft is small and the hypostomial bridge is as deep as the hypostomium, and conspicuous rectal scales are present.

Distribution

This species was uncommon in the Brazilian part of the focus (Table 1) occurring only in the highland localities (Auaris and Surucucus) and at Mucajai in the lowlands. In the Venezuela part of the focus *S. rorotaense* was found in highland (Parima B) and lowland (Peñascal) localities (Table 2). *Simulium rorotaense* is also recorded from areas of savanna and tropical forest in other parts of northern SouthAmerica. It occurs at locally high areas near Manaus in Brazil, on or adjacent to the Rorota plateau in French Guiana (Floch &Abonnenc, 1946b), around the Kaieteur Falls in western Guayana (Smart, 1940) and in the Gran Sabana in Bolivar state, Venezuela (Material Examined, Ramírez Pérez, 1983).

Simulium (Psilopelmia) suarezi Ramírez Pérez, Rassi and Ramírez

(Colour Plate 4, Fig. 128; Fig. 208)

Simulium suarezi Ramírez Pérez, Rassi & Ramírez, 1977: 173. SYNTYPE ♀ and associated pupal pelts (number not cited) VENEZUELA: Territorio Federal Amazonas (Venezuela), Departamento de Atabapo, Sierra de Parima, 1975 (J.Ramírez Pérez) (first author's private collection?)

FEMALE. No females were collected in the focus and none is available in the BMNH collection. Reference should be made to Ramírez Pérez *et al.* (1977) for a description of this stage.

MALE. General body colour orange. Body length (dry pinned specimen) 2.1 mm (n=1).

Coloration and morphology as in *S. rorotaense* (Colour Plate 4, Fig. 128) except scutum sometimes with indistinct pair of submedian, yellow comma-shaped marks extending from anterior margin for one third of scutal length, anterior portion highlighted with brown pigmentation. Abdominal tergite I velvet, dark brown/black; tergite II mid brown with paler patches along anterior margin.

PUPA. Gill length 1.2–1.3 mm (n=1).

A complete description cannot be given because of the lack of material.

Cocoon slightly shoe-shaped, mid to dark brown, with deep, looped, festoons at rim. Cocoon composed of thick, coarse, discrete fibres giving an open weave. Gill light brown, fan-shaped with 20 relatively short filaments, radiating out from main trunk in pairs (with bifurcation basal) or sometimes singly; filaments wide basally, tapering distally, their surfaces covered in spicules (Fig. 208). Frontoclypeus heavily covered in large round platelets. Thorax densely covered in large round platelets, the posterior half covered in much smaller, less distinct platelets.

LARVA. This stage has never been found.

Taxonomic discussion

Simulium suarezi is very similar to *S. rorotaense* although distinct in the male and pupa. Further material of all stages is required before its full relationship to other species can be established.

Distribution

This species has only been found in the Amazonia focus.

Simulium (Trichodagmia) guianense Wise

(Colour Plate 2, Fig. 34; Colour Plate 4, Figs 129,130; Figs 3,7, 14, 15, 45, 56, 67, 78, 89, 100, 111, 145, 156, 167, 178, 189, 209, 222, 236, 247, 258)

Simulium guianense Wise, 1911: 252. LECTOTYPE ♀, GUYANA: Essequibo River, 1908 (*Melville*) (BMNH) by designation of Smart (1940: 5).

Simulium pintoi d'Andretta & d'Andretta, 1945: 101. HOLOTYPE ♂, BRAZIL: São Paulo State, Salto de Piracicaba, Piracicaba, 28.vii.1944 (*Vulcano Andretta & Andretta Jr.*) (Depository unknown). **New synonymy**

Simulium ortizi Ramírez Pérez, 1971: 336. HOLOTYPE [sex unspecified but ♀] VENEZUELA: Bolivar State, San Felix, Rio Caroni, (no collection date) (*J. Ramírez Pérez*) (DERM). [Synonymy with *S. pintoi* by Ramírez Pérez *et al.*, 1982: 55]. **New synonymy**

FEMALE. General body colour black. Body length 1.9–3.3 mm ($\bar{x}$=2.7 mm, s.d.=0.3, n=59); wing length 1.7–2.7 mm ($\bar{x}$=2.2 mm, s.d.=0.2, n=56), wing width 0.7–1.5 mm ($\bar{x}$=1.0 mm, s.d.=0.1, n=51).

Head dichoptic with dark red eyes; nudiocular area well developed (Fig. 45). Frons, clypeus and occiput black with grey pruinosity; frons and clypeus with dense vestiture of recumbent brass-coloured setae. Mouthparts brown. Antennae dark brown with scape, pedicel and first flagellomere light brown. Cibarium unarmed (Fig. 56).

Scutum, including paranotal folds, scutellum and humeri dark grey with faint silvery grey pruinosity. Scutum and scutellum with numerous, short, broad, brass-coloured fine or scale-like setae arranged irregu-

larly in small groups (Colour Plate 2, Fig. 34); in freshly emerged specimens fine median line runs two thirds length of the scutum from the anterior border where no scales present. Pleural region dark grey and brown with silvery grey pruinosity. Postnotum dark grey with light silvery grey pruinosity.

Subcostal wing vein either bare or with up to six fine setae in distal half. Basal sector of Radius with single row of hairlike setae on basal two thirds, a single row of spine-like setae intespersed with hair-like setae on distal third (Fig. 67).

Legs brown and white banded as follows: fore leg with coxa, trochanter and femur light brown, tibia light brown with anterior surface white and upper border dark brown, and tarsus black; mid leg coxa dark grey pruinose, trochanter and femur light brown, tibia grey, basitarsus white with black distal articulation and rest of tarsi black; hind leg coxa dark grey pruinose, trochanter light brown, femur black, tibia black with distal articulation and outer distal half of margin white, basitarsus with basal three quarters white and distal quarter black, rest of tarsi black (Colour Plate 2, Fig. 34). Proportions of legs as in Fig. 3, showing expanded fore tarsi. Scale-like hairs on femora and tibiae of mid and hind legs as in *S. exiguum* (Fig. 4). Claws curved and slender without basal tooth (Fig. 78). Halteres light yellow with dark brown stem.

Abdominal tergites I–IV velvet black with silver pruinosity covering tergite II, tergites V–IX shiny black (Colour Plate 2, Fig. 34). Tergal plates well developed as in Fig. 5. Sternites and genitalia black. Eighth sternite highly sclerotised in posterior two thirds with 1+1 groups of 13–24 well developed setae, gonopophyses large, membranous and densely covered in fine setae (Fig. 89). Cerci hemispherical; paraprocts broadly quadrangular with dorsally exposed part sclerotised and more ventral part membranous with small tail-like projection pointing internally close to gonopophyses; whole paraproct densely covered in setae (Fig. 100). Genital fork (Fig. 111) short, with highly developed lateral arms and sclerotised anterior processes. Spermatheca oval, highly sclerotised, with internal sculpturing and few small spicules; width of membranous area of insertion of spermathecal duct large, about half maximum width of spermatheca (Fig. 7).

MALE. General body colour black. Body length 1.9–3.1 mm ($\bar{x}$=2.5 mm, s.d.=0.3, n=31); wing length 1.5–2.3 mm ($\bar{x}$=1.9 mm, s.d.=0.2, n=29); wing width 0.6–1.1 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=21).

Head holoptic with dark red eyes. Clypeus black with silvery grey pruinosity and many, long, dark, upright setae. Mouthparts black, antennae black with scape, pedicel and first flagellomere orange-brown.

Scutum velvet black with posterior third and lateral margins silvery grey; pair of submedian, silvery grey bands arising from posterior third and diverging near anterior border, merging with lateral silvery grey borders on anterior margin; this gives the appearance of a silvery grey scutum with a median velvet black band in the form of a capital T with the transverse stroke occupying the anterior border of the scutum and 1+1 lateral short velvet black bands occupying the median third of the scutum (Colour Plate 4, Fig. 129). The area of the black bands is variable, the form typically seen being that figured; this applies to all localities except Tapajos where the lateral bands are sometimes reduced to small circles or are absent (Colour Plate 4, Fig. 130). Humeri and paranotal folds black with silvery grey pruinosity. Scutellum velvet black on anterior half and black with silvery grey pruinosity on posterior half, postnotum black with silvery grey pruinosity. Pleural region black with silvery grey pruinosity. Scutum and postnotum covered in short, recumbent golden hairs.

Wing venation as in female except basal sector of Radius and Subcostal veins bare. Leg coloration as in female except light brown and grey areas black in fully coloured specimens; halter lemon yellow with orange-brown base.

Abdominal tergites velvet black, basal fringe light brown. Silver ornamentation as follows: tergite II all silver except for posterior edge and median area of posterior half of segment, most of lateral area of tergites V,VI & VII and lower margin of tergite VIII (Colour Plate 4, Fig. 129). Sternites yellowish brown with well developed black sternal plates on segments III–VIII. Genitalia dark brown. Gonocoxite subrectangular; gonostyle elongate, pyriform with large blunt distal spine (Fig. 145) and sometimes smaller accessory spine. Ventral plate sclerotised, rectangular with shallow, apical (posterior) depression, well developed basal (anterior) arms and setose ventral knobbed prolongation (Fig. 156). Median sclerite rectangular with deep incision at narrower apex (Fig. 167). Paramere poorly developed with no spines and little sclerotisation (Fig. 178).

Pupa. Cocoon length dorsally 2.0–3.1 mm ($\bar{x}$=2.5 mm, s.d.=0.3, n=35); ventrally 2.2–3.6 mm ($\bar{x}$=2.8 mm, s.d.=0.3, n=37); pupa length 1.9–3.1 mm ($\bar{x}$=2.4 mm, s.d.=0.3, n=37); gill length 0.5–0.9 mm ($\bar{x}$=0.7 mm, s.d.=0.1, n=36).

Cocoon shoe-shaped, light to dark brown; rim of aperture not reinforced and without central protuberance. Cocoon of smooth and gelatinous appearance with no obvious fibres (Fig. 189). Gill light brown with twelve filaments arranged in form of antlers (Fig. 209), main trunk giving rise to three primary branches, dorsal with six filaments, median with four filaments and ventral with two filaments. Branching of filaments in basal 2/3 of gill. Filaments short with distal dark pointed ends, their more distal surfaces with spicules

in annular arrangement. Head (frontoclypeus) with 2+2 small frontal unbranched trichomes, and 1+1 small, unbranched, facial trichomes; surface of head with scattered platelets on periphery and base of frontal region. Thorax with up to 4+4 simple or sometimes bifid, poorly developed, antero-dorsal trichomes. Surface of thorax with sparsely developed platelets mainly on dorsal and ventral margins. Abdominal tergite II with 4+4 fine hooks in line on posterior border of segment, tergite III–V with 4+4 well developed simple hooks, tergites VI–IX with patches of poorly developed spine combs on antero-lateral margins, tergite IX with no obvious terminal spines. Sternite IV with 1+1 simple short unsclerotised spines; sternite V with 2+2 bifid or sometimes trifid hooks, VI and VII with 2+2 bifid or trifid hooks; 1+1 patches of spine combs on postero-lateral borders of sternites IV–VIII.

MATURE LARVA. Body length 3.9–6.0 mm ($\bar{x}$=5.1 mm, s.d.=0.6, n=29); width of head capsule 0.5–0.7 mm ($\bar{x}$=0.6 mm, s.d.=0.05, n=28); length of head capsule 0.5–0.8 mm ($\bar{x}$=0.7 mm, s.d.=0.08, n=29).

Body colour usually white with greyish brown markings (Fig. 222) but occasionally completely creamy white.

Head light yellow and translucent with faint positive head spot pattern (Fig. 236) or head spots concolorous; chromatophores visible through cephalic apotome in many individuals. Head capsule with few, randomly distributed setae on all surfaces. Postgenal cleft large, as wide as long, rounded anteriorly, postgenal bridge about two thirds as long as hypostomium (Fig. 247). Hypostomium with strongly pigmented anterior margin and eight apical teeth: corner teeth large and blunt, pair of small median teeth, and four larger, blunt intermediate teeth; lateral serrations absent; 1+1 groups of five hypostomial setae parallel to lateral margins of hypostomium; surface of hypostomium with few short setae (Fig. 258). Antennae, long, unpigmented with segment ratios 35:10:22. Mandible with first three comb teeth decreasing in size posteriorly and two mandibular serrations, of which anterior is larger. Maxillary palp about three times as long as breadth at base. Cephalic fan with 32–40 rays (n=2).

Thorax cream with grey anterior collar and occasionally amorphous, grey central area on dorsum and grey central patch on venter of proleg and a single grey central patch on ventral surface of thorax posterior to proleg. Dorsal surface of cuticle, except for intersegmental margins, covered in numerous, small, platelet-shaped setae (Fig. 14) that appear simple under the light microscope ; ventral surface glabrous. Proleg plates lightly sclerotised with about twelve processes (Fig. 15). Pupal respiratory histoblast light brown and showing black pointed ends to filaments, claviform.

Abdomen cream with single complete grey ring on first four anterior narrow segments, more obvious dorsally; posterior segments grey dorsally with white intersegmental areas, whitish cream ventrally. Ventral nerve cord grey. Ventral papillae absent. Dorsal surface of cuticle, except for intersegmental margins, covered in short platelet-shaped setae; ventral surface glabrous except for some setae scattered around posterior venter of abdomen. Anal sclerite highly sclerotised with posterior arms extending to about 34th to 38th row of posterior circlet hooks. Posterior circlet with 143–151 rows of 5–30 hooks (n=7). Anal gill trilobed, each lobe with 10–12 finger-like lobules.

Taxonomic discussion

Wise (1911) first described *S. guianense* from eleven man-biting females collected by Melville on the Essequibo river and tributaries of its upper reaches in Guyana; all specimens had syntype status. According to Wise two syntypes were deposited in the Museum of the Royal Agricultural and Commercial Society of British Guiana but depositories for the remainder were not given.

In a subsequent redescription of *S. guianense* Smart (1940) examined one syntype deposited in the Liverpool School of Tropical Medicine (now in the Mersey County Museum, Liverpool) and four syntypes in the BMNH. He selected one of the latter as lectotype. We have examined the female lectotype and paralectotypes in the BMNH as well as immature stages and reared adults of *S. guianense* from the Brazilian onchocerciasis focus as a basis for the description.

The redescription of the female, and short descriptions of the male and pupa of *S. guianense* by Smart (1940, 1942) were based on material collected in 1937 by O.W. Richards and J.Smart from three localities on the R. Potaro, a tributary of the lower reaches of the Essequibo in Guyana. Smart considered these specimens to be conspecific with the type material of *S. guianense*. Not all the material examined by Smart had been subsequently deposited in the BMNH but the extant material shown under 'material examined' consists of: 21 female (20 reared but without pupal skins and one man-biting), 14 male (12 reared, but without pupal skins and two collected at lights), one dissected male pharate pupa and two pupal skins. Most of the material was pinned although some slide preparations were made by Smart. New preparations have now been made of some of this material and some of Smart's preparations have been remounted. All of Smart's specimens belong to a new species, *S. perplexum*, which has been described in detail elsewhere (Shelley *et al.* 1989b). The salient differences between *S. guianense* and *S. perplexum* are the morphology of the male and female genitalia and male scutal coloration as described and figured in Shelley *et al.* (1989b).

We have also examined the following material of *S. pintoi*: a pinned female paratype, its pupal skin and a slide preparation of its genitalia; a pinned male paratype and a slide of its genitalia; and two pupal skin paratypes on slides. This type material completely agrees with the detailed description of *S. pintoi* given by d'Andretta & d'Andretta (1945) as well as with the type material of female *S. guianense* and with conspecific reared adults and immature stages of this species from various parts of Brazil. Therefore, we synonymise *S. pintoi* with *S. guianense*. D'Andretta and d'Andretta (1945) discuss the previous confusion between this species and *S. orbitale*.

In 1971 Ramírez-Pérez described a new species, *S. ortizi*, from Bolivar State in Venezuela, noting its similarity to *S. guianense* but differentiating the two species on the form of the male genitalia as described by Smart (1940), and on minor differences in leg coloration from the description by Wise (1911) and from the lectotype (as 'holotype') and paralectotypes (as 'paratypes') in the BMNH. Later, Ramírez Pérez *et al.* (1982) synonymised *S. ortizi* with *S. pintoi* without given reasons. We agree with Ramírez Pérez's (1971) conclusion that *S. ortizi* differs from the description of the male '*S. guianense*' given by Smart (1940), which actually refers to the new species *S. perplexum*. We also agree with Ramírez Pérez *et al.* (1982) on morphological grounds that *S. pintoi* and *S. ortizi* are conspecific. Comparing the description of *S. ortizi* (op. cit.) with *S. guianense*, particularly in relation to the male terminalia, and taking into account normal variation in leg colour we consider the two taxa synonymous.

A morphological redescription of *S. guianense* from French Guiana by Floch and Abonnenc (1946b) entirely agrees with *S. guianense* except for coloration of the male scutum which appears similar to *S. perplexum* and the paraproct is not described in detail.

Coscarón (1991) suggested the synonymy of *S. albopictum* Lane and Porto with *S. pintoi* following examination of the female holotype and two paratype females deposited in the University of Sao Paulo, Brazil.

We have followed Crosskey (1988) in the subgeneric placement of *S. guianense* in *Trichodagmia*, a subgenus of which he considers *Thyrsopelma* and *Grenierella* junior synonyms. Coscaron (1987, 1991) maintained *Grenierella* and *Thyrsopelma* as subgenera and regarded *Trichodagmia* as a possible synonym of *Grenierella*.

Distribution

This species bites man more predominantly in highland localities (Auaris and Serra dos Surucucus), being present in only small numbers at Toototobi. Zoophilic populations were recorded at Catrimani and Mucajai. In the Venezuelan part of the focus *S. guianense* is anthropophilic in highland areas and zoophilic at lowland sites. *Simulium guianense* also occurs in other parts of Brazil, and in the Guianas and Venezuela (See Material Examined).

Simulium goeldii Cerqueira & Nunes de Mello

(Colour Plate 2, Fig. 35; Colour Plate 4, Fig. 131; Figs 46, 57, 68, 79, 90, 101, 112, 146, 157, 168, 179, 190, 210, 223, 237, 248, 259, 260)

Simulium goeldii Cerqueira & Nunes de Mello, 1967: 125. HOLOTYPE♀ and associated pupal pelt, BRAZIL: Amazonas State, Manaus, Igarapé do Tarumã, iii.1961 (*Cerqueira, Nunes de Mello and Vieira da Silva*) (INPA). [Holotype incorrectly cited as ♂ in description, female labelled as holotype in INPA collection. Dr V.Py-Daniel, personal communication]

Simulium scorzai Ramírez Pérez, 1980: 59. HOLOTYPE ♀ and associated pupal pelt, VENEZUELA: Amazonas State, Alto Ventuari, Cacuri, 350m (no collection date or collector) (INPA). [Synonymy by Ramírez Pérez, 1983: 9.]

FEMALE. General body colour black. Body length 1.1–2.3 mm ($\bar{x}$=1.8 mm, s.d.=0.3, n=14); wing length 1.5–2.0 mm ($\bar{x}$=1.8 mm, s.d.=0.2, n=10), wing width 0.7–1.0 mm ($\bar{x}$=0.8 mm, s.d.=0.1, n=9).

Head dichoptic with red eyes showing golden and green highlights; nudiocular area well developed (Fig. 46). Frons, clypeus and occiput black with silver pruinosity. Mouthparts mid brown, maxillary palps dark brown. Antennae dark brown with scape and pedicel orange. Cibarium with deep central trough armed and heavily sclerotised (Fig. 57); teeth small and numerous, becoming rounded towards centre of trough; large patch of tubercles in central region of trough.

Scutum black with silver pruinosity in wide band around lateral and posterior margins, and in narrow strip across posterior region of humeri (Colour Plate 2, Fig. 35). Humeri dark brown. Scutum with numerous, short, recumbent, golden setae. Scutellum dark brown with long dark hairs along posterior margin. Postnotum black with silver pruinosity. Paranotal folds black with silver pruinosity. Pleural region black with silver pruinosity.

Subcostal wing vein bare; basal section of Radius bare, distal two-thirds to half with about 17–20 coarse hairs or spines (Fig. 68). Costal tuft dark.

Fore coxa black with silver pruinosity, trochanter, femur and tibia mid brown (tibia paler basally, tarsi black. Mid coxa black with silver pruinosity, femur, tibia and tarsi mid brown (basal areas of tibia and basitarsus tending to be paler than distal areas). Hind

coxa black with silver pruinosity, trochanter mid brown, femur (sometimes paler basally), distal half of tibia, distal quarter of basitarsus, distal half of second tarsomere and remaining tarsi black, other areas yellow/white. Tarsi narrow as in *S. exiguum* (Fig. 2). Scales present on all femora and tibiae as in *S. exiguum* (Fig. 4). Claws curved with prominent sub-basal tooth. Halteres yellow/white with darker stems (Fig. 79).

Abdominal tergites black/brown. Tergal plates well developed. Tergite I velvet black/brown with fringe of dark hairs, slightly mottled orange/brown. Tergite II velvet black/brown with slight pruinosity and spot of silver pruinosity in central position on posterior margin and slight orange/brown mottling. Tergites III–VI velvet black/brown. Tergites VI–IX shiny brown with slight mottling. Sternites brown/grey. Genitalia brown. Eighth sternite with sclerotised posterior margin and group of about 10+10 setae lateral (five weak and five strong setae) (Fig. 90). Gonopophyses small, sclerotised on inner margin. Cerci hemispherical, paraprocts subtriangular with slight anterior extension, covered with long bristles and short dense setae (Fig. 101). Genital fork stout, stem sclerotised, arms poorly sclerotised and relatively short, triangular lateral processes well developed and poorly sclerotised (Fig. 112). Spermatheca round, sclerotised without external sculpturing, spicules on inner surface.

MALE. General body colour black. Body length 1.6–2.5 mm ($\bar{x}$=2.0 mm, s.d.=0.2, n=10); wing length 1.8–1.9 mm ($\bar{x}$=1.9 mm, s.d.<0.1, n=4); wing width 0.8–0.9 mm ($\bar{x}$=0.9 mm, s.d.<0.1, n=3).

Head holoptic with upper eye facets red and lower ones dark red (appearing black in dried specimens). Coloration of rest of head as in female.

Coloration and hairing of thorax and legs as in the female (Colour Plate 4, Fig. 131). Wing as in female except distal two thirds of Radius with 18–21, mainly coarse hairs and 1–2 spines.

Abdomen mainly velvet black/brown. Tergite I with fringe of shorter, dark hairs and longer, paler hairs. Tergite II slightly mottled with orange/brown at anterior margin and covered with silver pruinosity except in central region around tergal plate. Tergite V with pair of small, lateral, patches of silver pruinosity. Tergites VI–VIII with pair of lateral, silver, pruinose patches becoming progressively smaller (on tergite VI occupies most of lateral area whereas on tergite VIII occupies only one eighth of lateral area). Tergite IX brown. Sternites mid brown. Genitalia mid brown. Gonocoxite longer than wide; gonostyle subrectangular with stout, pointed distal spine (Fig. 146). Ventral plate with highly sclerotised, short, thick basal arms, keel small and covered in evenly distributed long fine hairs (Fig. 157). Median sclerite relatively short and broad, about three quarters as wide as long; basal end indented on either side (Fig. 168). Paramere with spines along distal half but only cluster at distal end strongly sclerotised; distal cluster contains one prominent spine (Fig. 179).

PUPA. Cocoon length dorsally 2.0–3.1 mm ($\bar{x}$=2.6 mm, s.d.=0.3, n=6); ventrally 2.1–3.2 mm ($\bar{x}$=2.7 mm, s.d.=0.4, n=6); pupa length 1.6–1.9 mm ($\bar{x}$=1.7 mm, s.d.=0.1, n=6); gill length 4.7–5.1 mm ($\bar{x}$=4.9 mm, s.d.=0.2, n=2).

Cocoon slipper-shaped, mid brown, reinforced at rim with prominent, short central protuberance (Fig. 190). Cocoon coarsely woven with individual fibres clearly marked. Gill light brown with 8 long, slender, forwardly directed filaments (Fig. 210). Main trunk bifurcates near base to two primary branches in vertical plane; ventral primary branch bifurcates at basal 1/8 of gill; dorsal primary branch bifurcates almost immediately at oblique angle with both upper and lower secondary branches then bifurcating at basal 1/8 in horizontal plane; outer filaments of both inner and outer tertiary branches then bifurcate in basal 1/3. Filaments with slightly crenated margins, rounded distally and with surface covered in fine spicules. Head (frontoclypeus) with 2 + 2 strong, bifid, frontal trichomes in basal third of frontal area, 1 + 1 well developed facial trichomes with 2–3 branches; surface covered with platelets, larger in frontal region. Thorax with 5 + 5 antero-dorsal, well developed, bifid trichomes. Surface covered with platelets, mainly restricted to anterior half. Abdominal tergite I with 1 + 1 simple hairs, positioned in middle of lateral margin; tergite II with 4 + 4 simple, weak hairs in line towards posterior margin, 1 + 1 simple hairs above outer hair in row, 1 + 1 patches of spine combs on anterior margin; tergite III with 4 + 4 simple hooks, 1 + 1 simple hairs above and between outer two and 1 + 1 antero-lateral patches of spine combs; tergite IV as III but lacking spine combs; tergite V with 5 + 5 fine hairs along posterior margin; tergite VI with 1 + 1 patches of weak antero-lateral spine combs; tergite VII with some fine spines combs along anterior region either side of a central gap and 1+1 lateral patches of fine spine combs; tergite VIII with anterior, continuous row of weak spine combs and spines and 1+1 lateral patches of spines combs; tergite IX with 1 + 1 small, rounded, sclerotised terminal spines, 1 + 1 row of spine combs towards anterior margin. Sternite III with central patch of small weak combs; sternite IV with 1 + 1 patches of weak spine combs towards lateral margins; sternite V with 2 + 2 weakly sclerotised trifid/quadrifid hooks towards posterior margin and 1 + 1 strong hairs at lateral margin; sternites VI and VII with 4 bifid/trifid hooks evenly spaced near posterior margin; sternites VIII and IX with spine combs along anterior margin.

MATURE LARVA. Body length 3.5–4.6 mm ($\bar{x}$=4.2 mm, s.d.=0.3, n=19); width of head capsule 0.4–0.6

mm ($\bar{x}$=0.5 mm, s.d.<0.1, n=19); length of head capsule 0.5–0.7 mm ($\bar{x}$=0.6 mm, s.d.<0.1, n=19).

Body colour pale white with grey markings (Fig. 223).

Head capsule pale brown with anterior third of cephalic apotome noticeably paler (almost white). Head pattern absent or slightly positive (Fig. 237). Some setae present on all surfaces. Postgenal cleft narrow at base, widening out with rounded apex (Fig. 248); slightly longer than wide at widest point. Postgenal bridge about half as long as hypostomium. Hypostomium with pigmented anterior concave margin and 9 apical teeth; corner teeth pointed and narrow and most prominent; median tooth small, often indistinct, and at base of concave trough; intermediate teeth masked by pigmented margin, usually one pair midway between corner teeth and mid point of hypostomium; 1–3 sharp serrations in lateral, pigmented area of hypostomium plus three lateral serrations occurring in anterior half of hypostomium; 1 + 1 group of four hypostomial setae lying parallel to margin plus 1 + 1 weak hairs at posterior end of row; surface of hypostomium with some short setae (Fig. 259). Antennae lightly pigmented with ratios 2:1:3. Mandible with first comb tooth largest, second and third teeth smaller and of equal size; two mandibular serrations of which anterior is larger, with slightly curved appearance and rounded extremity; posterior serration small and pointed; in area of mandible below apical teeth prominent, forked well developed antero-lateral process (Fig. 260). Maxillary palp about three times as long as wide at base. Cephalic fan with 36–41 rays (n=10).

Thorax white with grey patches above and beneath the proleg and with grey ring around anterior margin (sometimes with grey patches beneath histoblast). Cuticle with few setae. Proleg (see Fig. 15) with plates very lightly sclerotised and with 21 processes (n=1). Pupal respiratory histoblast dark brown, claviform.

Abdomen white with grey bands on anterior four segments, often more pronounced on segments I and IV; posterior segments with grey bands dorsally becoming amorphous patches ventrally. Ventral papillae large. Cuticular setae, few and indistinct. Anal sclerite with posterior arms extending to 10–11th row of posterior circlet hooks; anterior arms often narrow and weakly sclerotised. Posterior circlet with 61–65 rows of 2–11 hooks (n=5). Anal gill trilobed, each lobe with 8–9 long, finger-like projections.

Taxonomic discussion

This species was first described by Cerqueira & Nunes de Mello (1967) from collections made during their work on simuliid vectors of the filaria *Mansonella ozzardi* in the area around Manaus in the Brazilian Amazon. According to the publication it is based on a reared male holotype and pupal pelt (No. 2184–1), and reared female, pupal and larval paratypes. These were deposited in the insect collection at INPA but were not subsequently located in this depository (Shelley *et al.*, 1984). Py-Daniel (1981) examined specimen 2184–1, but referred to a female holotype (No 2185–3). It transpires that the type series has now been found and that a female was labelled as holotype (Dr V.Py-Daniel, personal communication, 26.VI.1995). The distinctive scutal pattern of the adults facilitates identification of this species from sympatric species and no synonyms have been recognised for it in Brazil. However, Ramírez Pérez (1980) and Ramírez Pérez *et al.*, (1982) described a new species, *S. scorzai*, from Venezuela, which he separated from *S. goeldii* on a minor difference in configuration of the pupal gill. Examination of a reared topotype of *S. goeldii* and a reared female paratype of *S. scorzai* led Shelley *et al.* (1984) to accept the synonymy of the two species suggested by Ramírez Pérez (1983).

The subgeneric position of *S. goeldii* was discussed by Py-Daniel (1981). He maintained that it does not clearly belong to any neotropical subgenus, a conclusion with which we agree. Crosskey (1988) does not assign it to a subgenus in his world check list but Coscaron (1987) includes it in *Coscaroniellum*.

Cerqueira & Nunes de Mello (1967) referred to the presence of a well developed antero-lateral process on the larval mandible of *S. goeldii*. Py-Daniel (1981) later named this feature as the lateral mandibular process, which he maintained can be used for separating tribes. The character is particularly well developed and can be used in the onchocerciasis focus to distinguish larvae of *S. goeldii* from sympatric species in which it is lacking or simple.

Distribution

This species was only collected from the Igarapé da Floresta and the stream by the abandoned mission post at Serra dos Surucucus (Table 1). It was not recorded from the Venezuelan side of the focus (Table 2). Elsewhere in Brazil it occurs in the savannas west of Boa Vista, Roraima and in localities in Amapá, Amazonas, Rondonia, and Pará (Cerqueira & Nunes de Mello, 1967; Dellome Filho, 1983; Material Examined). The only other record of this species is from Venezuela in southern and northern Amazonas Territory (Ramírez Pérez, 1983).

DISTRIBUTION AND BIOLOGY

The distribution of simuliid species in the Brazilian part of the focus is shown in Table 1 and Maps 2, 3. Nine species are present in the lowland localities: *S. cauchense, S. exiguum, S. guianense, S. incrustatum,*

S. iracouboense, S. oyapockense, S. roraimense, S. quadrifidum and *S. rorotaense*. All these species, except *S. iracouboense*, also occur in the two highland localities together with five additional species: *S. bipunctatum, S. goeldii, S. lutzianum, S. rubrithorax* and *S. suarezi*.

The distribution of simuliids in the Upper Orinoco area of the Venezuelan part of the focus is recorded in Table 2 and Maps 2, 3. The fauna of lowland localities is the same as Brazil, except for the absence of *S. quadrifidum* and *S. incrustatum* and the presence of *S. limbatum*. In the three highland Venezuelan localities all the species found in similar localities in Brazil occurred with the exception of *S. goeldii* and *S. rubrithorax* and the addition of *S. beaupertuyi, S. covagarciai, S. morae, S. matteabranchia, S. perflavum* and *S. parimaense*. Simuliid species identified as *S. pintoi* or *S. guianense, S. exiguum, S. incrustatum, S. oyapockense* and *S. amazonicum* were recorded in the Upper Caura area in Bolivar State (Godoy *et al.*, 1989), while on the adjacent R. Ventuari Ramírez Pérez *et al.* (1977) recorded *S. clarki* as the only anthropophilic species present together with the new species *S. nuneztovari*.

Despite the variation in geology, soils and vegetation recorded in the Brazilian part of the focus the only obvious effect on simuliid species distribution, species diversity and predominance is that of altitude. This is best illustrated in the anthropophilic species, whose predominance is more easy to quantify through biting catches. Six of the 14 species recorded for the Brazilian part of the focus were anthropophilic: *S. bipunctatum, S. exiguum, S. guianense, S. incrustatum, S. oyapockense/roraimense* and *S. rorotaense*. Of these *S. bipunctatum* (Auaris) and *S. rorotaense* (Auaris and Surucucus) occurred in such low numbers as to be of no epidemiological importance. The variation in predominance of anthropophilic species was as follows (Table 3); *S. guianense* and *S. incrustatum* were the principal species at higher altitudes (Auaris and Surucucus) and *S. oyapockense/roraimense* in lowland forest localities (Toototobi, Catrimani, Mucajai, Parimiu) accompanied by *S. exiguum* at certain seasons in Toototobi and Catrimani. In Venezuela all the above species were anthropophilic except *S. rorotaense*. The same predominance of species in highland (Parima A and B) areas and lowland areas (Tama Tama, Boca de Ocamo, Boca de Mavaca, Platanal to Rio Orinoquito on Upper Orinoco river), was noted in Venezuela. However, at Coyowe-teri (Orinoquito) in the Parima foothills and hence similar to Parimiu and Mucajai & Catrimani in Brazil, a situation similar to highland areas was seen with *S. guianense* predominant and *S. incrustatum* the other main anthropophilic species (Basáñez *et al.*, 1988, Rassi *et al.*, 1977; Tada, 1983).

Studies on the biology of species in the Brazilian part of the focus were principally directed at those that were anthropophilic. Data on the biology of each species follow the order used in the Systematics section.

Simulium rubrithorax

In the Amazonia focus *Simulium rubrithorax* is probably zoophilic as in other parts of Brazil where it bites horses and most probably cattle. Yanomami Indians in the focus use larvae collected from a local waterfall as a food source (Shelley & Luna Dias, 1989). *Simulium rubrithorax* breeds in fast-flowing water (particularly in waterfalls), where larvae and pupae can be found attached to rocks, often in enormous numbers (Maia-Herzog *et al.*, 1984).

Simulium exiguum

The behaviour of *S. exiguum* appears to vary at different localities. This species was largely zoophilic during the dry season when immature stages were abundant in the rivers Catrimani and Mucajai, whereas at Toototobi it was the most abundant when the river level was at its lowest, although breeding grounds were not located. Then, it was the most prevalent anthropophilic species biting man throughout the day with the main activity peak around midday (Fig. 265). In contrast, at Catrimani it was more abundant biting man in the wet season with high biting rates (Table 3) and peak biting activity in the afternoon (Fig. 265). At this locality *S. exiguum* was commonly collected in the dry season in the river attached to Podostemaceae growing on rocks in rapids, but was largely zoophilic at this time. In the Venezuelan part of the focus *S. exiguum* bit man in low numbers (Tada, 1983).

In other parts of Brazil *S. exiguum* is apparently zoophilic in many of the larger rivers of Roraima (Uraricoeira, Surumu, Branco), but has been found biting man at Aripuaña, Mato Grosso (Lacey & Charlwood, 1980). Immature stages occur on Podostemaceae in rapids in Brazil in contrast to the known breeding grounds in Ecuador where Podostemaceae are absent and fallen leaves and submerged trees in large rivers are favoured (Shelley *et al.*, 1989a). Similar behaviour differences have been noted in other countries of Latin America and this may possibly be associated with the presence of a sibling species complex (Procunier *et al.*, 1985; Shelley *et al.*, 1989a).

Simulium quadrifidum

This species is totally zoophilic and so has been little studied except for taxonomic reasons. Its typical breeding grounds are slow to medium-flowing, shaded, forest streams where it never occurs in very large numbers, immature stages being found on fallen leaves and submerged tree roots.

Simulium cauchense

Simulium cauchense is zoophilic and typically breeds in small streams with a slow to medium flow in lowland forest, where immature stages are found on submerged vegetation.

Simulium oyapockense/roraimense

Simulium oyapockense/roraimense is anthropophilic and can bite in large numbers, examples of biting densities being 6780 flies per man/day at Catrimani, more than 200 in 15 minutes at Parimiu and 302 between 1100 and 1200 hours at Mucajai. Such enormous numbers can occur as to make visits to the riverside unbearable. Population size is related to season with largest numbers occurring during the rains at Catrimani and Tootototbi (Table 3). This is directly related to river depth as indicated in Fig. 266 showing data from Tootototbi. This species bit man throughout the day from dawn to dusk, generally with a bimodal cycle with mid morning and mid afternoon peaks (Figs 261, 262, 263). In Venezuela, as in Brazil, *S. oyapockense/roraimense* is the predominant anthropophilic species in lowland forest areas but is also present biting in low numbers in highland areas. Suárez *et al.* (1992) found *S. oyapockense/roraimense* biting man at Siapa III and Boca da Mavaca in Venezuela. Similar biting cycles and seasonal densities in relation to precipitation and water level in rivers have been observed for this species at Uruá in Pará, Brazil where numbers can be so high as to prevent agricultural work (Lacey, 1981, as *sanguineum*). However, at Aripuaña, Mato Grosso this species showed three peaks of activity (Lacey & Charlwood, 1980).

Biting catches were always located close to the river where it had previously been shown that high numbers of flies could be collected. Biting was also recorded in clearings for plantations or landing strips for aircraft but never in dense forest. This species also entered houses to bite when populations were high as recorded by Lacey (1981) at Uruá. A preference for biting above the waist (64.2% of 1983 flies collected), compared to below the waist (35.8%) where microfilarial densities are known to be highest (Moraes *et al.*, 1979) was shown with standing volunteers at Tootototbi. However, at Catrimani such a clear cut pattern was not obvious. With two seated volunteers, wearing only short trousers, 83.6% of 360 flies on one and 43.2% of 340 on the other were collected from above the waist, whereas with the volunteers standing 77.3% of 480 flies on one and 52.7% of 336 on the other bit above the waist. Tada (1983, as *amazonicum* group) found more flies biting above the waist in Venezuela but only low numbers were collected. Lacey & Charlwood (1980, as *sanguineum s.l.*) recorded similar variation for this species at Uruá with biting mainly above the waist, but at Aripuaña equally above and below the waist. Two females and one male were collected in a light-trap at Auaris.

The limited dissections for parity showed the expected seasonal differences. During the wet season (December 1975 and October 1976) at Tootototbi when *S. oyapockense/roraimense* populations were high 18 flies collected at 1700–1800 were all nullipars and 50 of 51 flies dissected randomly throughout the day were nullipars. Conversely, in February 1976 when the R. Tootototbi was low and the fly population declining 79.3% of 319 flies dissected were parous and 20.7% nulliparous; nullipars occurred throughout the day with a bimodal biting cycle (Fig. 261). However, in the dry season (January 1979) at Catrimani most flies were nulliparous (470) although parous (87)flies bit throughout the day; the proportion of parous to nulliparous was considerably higher from sunrise to midday (169:74) than from midday to dusk (301:13). Parous flies were discriminated by the presence of relicts (generally single but up to 3 observed), the less elastic and more opaque ovarioles and the occasional presence of fully developed eggs left from the last oviposition.

The breeding grounds of this species were difficult to find within the focus. Despite high biting densities at Tootototbi only a single pupa was collected (*S. oyapockense*) following intensive prospecting. Larger numbers of larvae and pupae were found attached to Podostemaceae in rapids at Mucajai (*S. oyapockense*) and Catrimani (*S. roraimense*) towards the end of the wet season when the rivers were rapidly descending, and in the dry season. During the wet season when rivers are in spate and this species has high man-biting populations, sampling for immature stages is impossible because of the high current speed in larger rivers with rapids (Catrimani, Mucajai) and the inundation of adjacent forest in smaller rivers (Tootototbi) with innumerable potential habitats to search. It is probable that during the dry season breeding is largely confined to rapids but as rivers increase in volume during the rains and flood their banks, inundating the jungle, flies lay eggs on submerged vegetation resulting in more diffuse breeding grounds.

Simulium incrustatum

Simulium incrustatum was collected biting man in low numbers in the wet season at the lowland Mucajai site. At Auaris it was the predominant species in the wet season (Table 3) and bit throughout the day with a peak of activity around midday (Fig. 264). Biting occurred almost equally above (57.4% of 773 flies) and below (42.6%) the waist. Larvae and pupae of *S. incrustatum* were only collected from the R. Auaris in the wet season where they were found in low numbers on submerged leaves and from the Igarapé da Floresta and the stream by the abandoned mission post at the Serra dos Surucucus.

Simulium incrustatum was more abundant in two highland localities in the Venezuelan part of the focus, biting man either mainly above the waist (Tada, 1983) or in almost equal proportions above and below (Basáñez *et al.*, 1988).

Simulium incrustatum is a common, widespread species in Central and Southern Brazil (See Material Examined) that varies in its biting behaviour, being anthropophilic at some localities but totally zoophilic elsewhere. Lutz (1910) collected this species biting horses at various localities in south-east Brazil and found it breeding in small streams and rivers in highlands. Elsewhere in South America it bites man (Coscaron, 1987, 1991) and in Ecuador may be associated with onchocerciasis transmission at Naranjal on the R. Canandé (M.Arzube & A.J.Shelley, personal communication). Dellome Filho (1989, 1991) describes the gut contents of this species and various physical and chemical properties of the river in which it was found in southern Brazil.

The variations in morphology and behaviour suggest the presence of a sibling species complex.

Simulium bipunctatum

This species was collected biting man in small numbers in the rainy season in Auaris (Table 1) and at Parima A and B in Venezuela (Table 2). Its breeding grounds were not located in Brazil but immature stages were found in forest streams in Venezuela (Ramírez Pérez *et al.*, 1982).

The biting habits of *S.bipunctatum* are variable. In the onchocerciasis focus of Ecuador (Shelley & Arzube, 1985) and in the majority of the Caribbean Islands and Mexico (Shelley *et al.*, 1989b) it is mainly zoophilic, only rarely coming to bite man. However, it is markedly anthropophilic in the Upper Amazon region of Brazil along the R. Vaupes (Material Examined) and in parts of Guadeloupe it can also be a biting nuisance (Floch & Abonnenc, 1946a) and recently has been found biting man in the Galapagos Islands of Ecuador (Abedraabo *et al.*, 1993).

Simulium bipunctatum breeds in shaded, slow-flowing streams in lowland forest of Ecuador (Shelley & Arzube, 1985), in fast flowing small streams in St Croix and Jamaica, in small streams up to an altitude of 1200m throughout the year in Cuba (Shelley *et al.*, 1989b), and in small forest streams in Venezuela (Ramírez Pérez *et al.*, 1982).

Simulium iracouboense

This commonly occurring large river breeder is zoophilic. In the dry season it is found on various species of Podostemaceae in enormous numbers and was the only *Simulium* species to be collected on a broad-leafed species of Podostemaceae at Mucajai. During the wet season sampling of breeding grounds is impossible.

Simulium lutzianum

The species is apparently totally zoophilic in Ecuador (Shelley & Arzube, 1985) and there are no records of it attacking man elsewhere except [as *S. lewisi*] at Morretes in Parana State, southern Brazil by Dellome Filho (1991).

In the Amazonia focus *S. lutzianum* breeds on submerged and trailing vegetation in slow to medium flowing streams and rivers. In Ecuador it occurs in small, shaded streams and in rivers up to 100m wide in lowland tropical forest either side of the Andean cordillera (Shelley *et al.*, 1989a) and in similar water courses in lowland areas in central and western Venezuela (Coscarón, 1991; Ramírez Pérez, 1971).

Simulium rorotaense

Simulium rorotaense was recorded biting man in Auaris but not in the Venezuelan part of the focus. Although occurring in highland areas of the Amazonia onchocerciasis focus of Brazil and Venezuela its presence in low numbers precludes it as a potentially significant vector of onchocerciasis. It is also recorded as biting man in French Guiana (Floch and Abonnenc, 1946b) and in Bolivar State, Venezuela [as *S. wuayaraka*] (Ortiz, 1957).

This species breeds in small numbers in streams and small rivers with medium current speed on submerged vegetation (Floch & Abonnenc, 1946b, current data). Larvae and pupae are found on fallen leaves and submerged roots in muddy or rocky bottomed, shaded forest streams in both highland (Auaris-Igarapé Hutumati, and Serra dos Surucucus-Igarapés Falemu and Majeba) and lowland (Mucajai-Igarapé Coroconai) localities as well as on Podostemaceae in the R. Mucajai. In the Venezuelan part of the focus immature stages were collected in both types of habitat in both highland (Parima B) and lowland (Peñascal) localities. The larval diet and feeding mechanisms, larval predators and larval instars (8), oviposition and egg incubation and habitat choice (shaded forest streams) were studied near Manaus in Brazil (Cerqueira & Nunes de Mello, 1968; Dellome, 1978; Gorayeb, 1981; Gorayeb & Pinger, 1978; Lacey & Lacey, 1983).

Simulium guianense

Biting catches made at Auaris during the transition of dry to wet season (March 1977) and the middle of the wet season (July 1976) close to the R. Auaris showed *S. guianense* to be the predominant anthropophilic species in the former season (Table 3). Biting occurred throughout the day with a small peak of activity in mid morning and a much larger peak in mid afternoon (Fig. 264) with the lower parts of the body being the preferred biting site.

In Venezuela similar observations on population density (184 per man per day) and biting mainly below the waist have been recorded (Basáñez *et al.*, 1989; Tada, 1983) for highland localities. At lowland localities biting frequency was very low and several pupae were collected at rapids at Peñascal (Table 2).

In studies at Uruá in Pará, Brazil, Lacey (1981) and Lacey & Charlwood (1980) showed *S. guianense* to have a bimodal biting cycle, to enter houses to bite and to be more abundant in the transition between wet and dry season when rivers were not in full flood; 62.5% of the 761 flies collected bit below the waist. Tada (1983) recorded *S. guianense* biting cattle, horses and dogs in Parima B in Venezuela. Smart (1940) referred to probable biting but was dealing with the closely related *S. perplexum*. Wise (1911), who first described *S. guianense*, did not refer to its biting habits.

The variation in biting behaviour and medical importance of *S. guianense* indicate a probable species complex requiring urgent investigation because of its medical importance.

The breeding grounds of *S. guianense* have not yet been located in either the Brazilian or Venezuelan part of the Amazonia focus at highland localities where anthropophilic populations occur. This species occurs in large numbers breeding in rapids on Podostemaceae in both Catrimani and Mucajai but is totally zoophilic there (Table 1). Similarly, in the Venezuelan part of the focus breeding grounds have been located in lowland areas (Table 2). Outside the focus it is a common zoophilic species (see Material Examined) in large rivers with rapids and Podostemaceae; anthropophilic populations where breeding grounds have been found occur on the R. Tocantins near Minaçu and on the R. Anapu on the TransAmazon Highway in Pará.

Simulium goeldii

Simulium goeldii is totally zoophilic, occurring in small numbers especially at the beginning and end of the rainy season in slow-flowing creeks and streams (current data, Cerqueira & Nunes de Mello, 1967) from 100–350m altitude in savanna and forested areas. Studies on the physical and chemical factors that may affect its distribution indicate that it appears to favour streams with a high humic acid content (pH 3.6–5.3) (Dellome Filho, 1983) and that larvae are more commonly found on submerged green vegetation than roots and dead leaves (Hamada, 1989).

Other simuliid species

Other simuliid species occur in the Amazonia focus in very low numbers in the highlands. In Brazil the zoophilic *S. suarezi* was collected from the R. Auaris in the wet season (Table 1). In Venezuela *S. beaupertuyi, clarki, matteabranchia, morae, perflavum, parimaense* and *suarezi* were collected in rivers of the Parima highlands and were apparently zoophilic.

PARASITOLOGICAL FINDINGS AND EPIDEMIOLOGICAL IMPLICATIONS

Introduction

Following the identification of simuliids at localities in the Brazilian part of the onchocerciasis focus in the 1970s, anthropophilic species that occurred in large numbers were experimentally infected with *O. volvulus* to test their potential as hosts. Wild flies collected in biting catches were dissected and examined for L3 larvae of *O. volvulus* to discover which species were responsible for transmission. Since the identification of simuliids in the Amazonia focus was uncertain at the time of this work several cases occurred of the same species being given different names depending on whether it was collected in the Brazilian or Venezuelan part of the focus. Table 4 lists these names for clarification. At this time Rassi *et al.* (1977) had found *S. guianense* (as *pintoi*) and *S. oyapockense/roraimense* (as *amazonicum*) naturally infected with infective *O. volvulus* larvae at a highland forest area (Coyowe-teri) and a lowland forest area (Platanal) in Venezuela respectively. Subsequent review articles (Ramírez Pérez, 1983, 1984, 1985, 1986) initially questioned the identity of the filaria, believing it to be *M. ozzardi*, but later cited the species as *O. volvulus*. Although low prevalence rates of mansonelliasis do occur in the Parima mountains, more recent work (Basáñez *et al.*, 1989) has now confirmed the original findings of Rassi *et al.* (1977) for *S. guianense*.

Experimental Infection with *O. volvulus*

In Brazil the development of *O. volvulus* in *S. oyapockense/roraimense* was compared at the lowland localities of Mucajai, Toototobi and Catrimani in the onchocerciasis focus and at Cachoeira on the R. Cauamé in the adjacent, non endemic savanna (Shelley *et al.*, 1987b). No conclusions could be drawn from the work at Mucajai because the volunteer had a very low level infection and few flies took up microfilariae. In all other localities large numbers of microfilariae were ingested, possibly as a result of a concentration effect associated with a substance in the fly's saliva (Shelley *et al.*, 1979b). However, more recent work by Basáñez *et al.* (1994) has shown that microfilarial intake is more closely associated with skin microfilarial densities if biopsies are incubated for a period longer than that traditionally used, thereby allowing larger numbers of microfilariae to emerge. Up to 2.4% of these microfilariae survived the damage caused by the

cibarial teeth on their passage in the blood meal through the head and developed rapidly to the infective stage in a synchronous cycle. *Simulium limbatum*, another anthropophilic species from the non-endemic savanna area, showed a similarly low host capacity as *S. oyapockense/roraimense* because of the presence of cibarial teeth. Comparison of later data from Venezuela with those from Brazil is not possible because in Venezuela a sclerocorneal punch was used to remove a uniform area of skin whereas in Brazil weighed skin biopsies of varying areas were used for calculating skin microfilarial densities in man. Only low numbers of flies were experimentally infected in Venezuela and development of parasites to the L3 stage was not observed in *S. oyapockense/roraimense* (Basáñez *et al.*, 1989). Experimental infection of *S. guianense* and *S. incrustatum* was unsuccessful in the highland locality of Auaris in Brazil because microfilariae only succeeded in developing to the L1 stage before flies succumbed to bacterial and fungal infections (Shelley *et al.*, 1987b). Later studies at Parima in Venezuela (Takaoka *et al.*, 1984) revealed that *S. guianense* [as *pintoi*] did not concentrate microfilariae when feeding and that full development of the parasite to the infective stage occurred in a rapid, synchronous cycle. However, mortality rates greatly increased when flies ingested large numbers of microfilariae from a volunteer with high skin densities of the parasite as this simuliid species possesses no cibarial teeth. Basañez *et al.* (1989) found a less synchronous development cycle in *S. guianense* at the same locality with L1 larvae still commonly found in infected flies one week after experimental infection. The latter authors also showed that *S. incrustatum* [as *S. limbatum* and *S. yarzabali*; actual species not confirmed, see section on distribution of *S. incrustatum*] allowed development of *O. volvulus* microfilariae to the infective stage but to a far lesser extent than *S. guianense* [as *S. pintoi*] because of damage by the cibarial teeth. Experimental infection of *S. bipunctatum* [as *S. antillarum* and *S. pseudoantillarum*] was inconclusive because of low numbers.

Natural Infection Rates with *O. volvulus*

Results of dissections for natural infection rates for both highland and lowland localities in Brazil are shown in Table 5. Natural infection rates were low in *S. oyapockense/roraimense*, the predominant anthropophilic species at the lowland forest localities. At Toototobi, with high prevalence rates and skin microfilarial densities a low overall infection rate of 0.5% was recorded with an infective larva of *O. volvulus* (proving natural transmission) being found in a fly during the dry season when parous rates were higher. A similar low overall infection rate of 0.5% was recorded at Catrimani in the dry season, when one fly was found with an L3 of *O. volvulus* in its head; in the wet season a lower overall infection rate of 0.2% was recorded. At the highland locality of Auaris no infections occurred in the small numbers of this species biting man at the beginning of the wet season. *Simulium guianense*, the most important anthropophilic species in the dry season at Auaris showed a 3% infection rate with an L3 larva present in one fly; only two adults of this species were collected at Toototobi and both were negative for filariae (Table 5). During the wet season at Auaris *S. incrustatum* predominated and showed an infection rate of 1.3% with one of the filariae being an infective larva of *O. volvulus*. These data indicate that both *S. guianense* and *S. incrustatum* are natural vectors of *O. volvulus* at Auaris. A fourth anthropophilic species, *Simulium exiguum* was dissected for parasites from both Toototobi and Auaris. During a dry period at the former locality relatively large numbers of this species occurred of which 1.5% were infected with filarial larvae in the L1 stage and one fly contained four infective filarial larvae of an unknown species in the head. Despite the low numbers of flies biting in the wet season at Toototobi and the dry/wet season interface at Auaris, L1 filarial larvae occurred in flies at both localities. It is possible that *S. exiguum* is a vector of *O. volvulus* and other filaria species at Toototobi and Auaris and of *M. ozzardi* at the latter locality. This species bites in large numbers at Catrimani in the wet season and also breeds in large rivers outside the focus (R. Uraricoeira, Surumu, Branco). Its host capacity for *O. volvulus* should be tested because a close relative (*S. exiguum* 'Cayapa' cytospecies) is an extremely efficient primary vector of the parasite in Ecuador (Shelley, 1988a; Shelley *et al.*, 1990).

The conclusions from these infectivity rates in relation to host capacities of anthropophilic species and prevalence rates of *O. volvulus* in man is that in the highland (mainly hyperendemic) areas *S. guianense* is the main efficient vector and *S. incrustatum* a more inefficient secondary vector; in lowland forest *S. oyapockense/roraimense* is the primary, albeit poor vector in these mainly hypoendemic localities. The hyperendemicity at Toototobi is presumably due to the frequent visits of Indians to neighbouring mountainous areas where *S. guianense* probably occurs.

On the Venezuelan side of the focus Rassi *et al.* (1977) found infection and infectivity rates of 8% and 2% in 100 *S. guianense* at Coyowe-teri and one fly (0.25%) of 400 *S. oyapockense/roraimense* with an infective larva of *O. volvulus* at Platanal at the end of the dry season in 1975 (Table 6). Later work confirmed these findings for *S. guianense*. In October–November 1982 Tada (1983) recorded an infection rate of 4.7% (21 in 447 dissected) in *S. guianense* at Parima B with up to 13 L1 larvae in each fly and one with an L3 of *O. volvulus*. Similar infection and infectivity rates have been recorded by other workers at Parima B and

Coyowe-teri (Orinoquito) (Basáñez *et al.*, 1988; Basáñez & Yarzábal, 1989; Table 6). A female *S. bipunctatum* was found naturally infected with infective larvae of *Ornithofilaria* species.

Epidemiology and Control

Data collected during the 1970s and summarised at the beginning of this paper showed that onchocerciasis in the Amazonia focus is centred on the Parima mountain range and affected a large number of communities in most of the Yanomami territory of Brazil and Venezuela. Localities where the disease is hyperendemic are almost exclusively found in highland areas, whereas the disease is largely hypoendemic in lowland areas. This pattern of endemicity coincides with the distribution of the three main simuliid vectors in the focus. *Simulium guianense* only occurs significantly in highland areas where it is a highly efficient vector and is largely responsible for parasite transmission; *S. incrustatum* is also found mainly in highland localities but only as a secondary vector there. *Simulium oyapockense/roraimense* is the only important, albeit poor vector in the lowland, mainly hypoendemic localities. An attempt at adult parasite control using suramin in Brazil had to be curtailed because of potential toxic effects of the drug and the logistical difficulties involved in application and surveillance of effects. The microfilaricide ivermectin was not available for use in man at this time. Definition of the distribution and severity of the disease, and incrimination of the vector simuliid species, and to a limited extent their distribution, allowed links between vector species and disease endemicity to be explored and the potential for dispersal to be evaluated.

The numerous factors that affect onchocerciasis transmission in Latin America are reviewed by Shelley (1991) and Shelley *et al.* (1987b). One critical character, the presence or absence of teeth in the female cibarium, has been used to divide into two groups eight of the 12 Latin American vectors for which sufficient experimental infection data exist. It was concluded that species possessing cibarial teeth (that damage *O. volvulus* microfilariae ingested as the fly feeds e.g. *haematopotum, ochraceum s.l., oyapockense s.l., roraimense*) can only function as efficient vectors in hyperendemic situations and cannot be responsible for a rapid increase in endemicity in hypoendemic areas. Examples cited are Guatemala where *S. ochraceum s.l.* is shown to be an experimentally poor vector responsible for low parasite transmission in hypoendemic areas although efficiently transmitting *O. volvulus* in hyperendemic localities and Brazil where low endemicity persisted in lowland areas of the focus despite high biting densities of *S. oyapockense s.l./roraimense*. However, experimental infection studies showed that species without cibarial teeth (*callidum, exiguum s.l., guianense s.l., metallicum s.l.*) could potentially be efficient vectors if other factors such as parasite susceptibility to host, vector anthropophily and biting densities are high and it is this group that could be responsible for a rapid increase in prevalence rates in hypoendemic areas. Guderian and Shelley (1992) cited the high vectorial capacity of *S. exiguum s.l.* as a major factor responsible for the transition of a hypoendemic to a mesoendemic situation of a satellite onchocerciasis focus in Ecuador. Similarly, we believe that the discrete distribution of *S. guianense* (as effective a vector as *S. exiguum s.l.*) in the Amazonia focus is responsible for the existence of onchocerciasis hyperendemicity only in or closely adjacent to highland localities. In support of this hypothesis is a recent analysis (Basáñez *et al.*, 1995) using our data for *S. oyapockense s.l./roraimense* from Brazil, those of Takaoka *et al.* (1984) and Basáñez (unpublished) for *S. guianense* from the Venezuelan part of the focus and from various authors for *S. ochraceum s.l.* from Guatemala and *S. damnosum s.l.* from Africa.

Dispersal of the disease in the 1970s could theoretically have occurred by the migration of infected flies or of infected people from the focus to non-endemic areas; new foci would have become established if efficient vector species were present. Since *S. guianense* and *S. incrustatum* have restricted distributions in the central highland area of the focus, dispersal of infected flies to non endemic areas adjacent to the focus seems highly unlikely. Anthropophilic species found in the lowland areas of the focus and in the adjacent non-endemic area of Brazil are the same, and although the migratory habits of the only vector, *S. oyapockense/roraimense*, were not known, this species was shown to be a poor vector with low infectivity rates (Table 5) that had little effect on disease endemicity over a considerable period (Moraes *et al.*, 1986). Hence the migration of infected flies from endemic to non-endemic areas is highly improbable. The possibility that infected people could leave the focus for the area around Boa Vista in Brazil and set up a new focus was investigated by Shelley *et al.* (1987b). They showed that the common anthropophilic species in this area (*S. limbatum*, *S. oyapockense s.l.* and *S. roraimense*) bit man in significantly high numbers, but that all three are poor hosts to *O. volvulus* because they possess cibarial teeth. Therefore, only in the unlikely event of a mass ingress of highly infected individuals into these non-endemic areas would a new disease focus form. This, too, was unlikely because the potential passage of infected Indians along the Northern Perimeter Road to the vicinity of Boa Vista in Roraima became almost impossible when the road became impassable in many places. Onchocerciasis, because of its isolation, then became an almost forgotten disease in Brazil, interest only being revived ten years ago with its re-appear-

ance at Minaçu, Goias. Here it is believed (Shelley, 1988) to have been introduced by miners from Minaçu, who probably contracted the disease at the Serra dos Surucucus in the 1970s and then returned home and provided a source of infection to a local potential vector *S. guianense*. This resulted in the transmission of the parasite to a local girl. The examination of 2500 skin biopsies by the Ministry of Health detected no more cases of onchocerciasis but a more recent survey using a serological technique (Bradley *et al.*, 1993) on blood samples of 400 people showed eight to have been in contact with the parasite (Shelley, Bradley, Lowry, Luna Dias, Maia-Herzog, unpublished data). Preliminary surveys of simuliids in the R. Tocantins and its tributaries in the area showed the presence of the following anthropophilic species: *S. guianense*, *S. exiguum s.l.* and *S. minusculum*, a species related to *S. oyapockense s.l.* (Shelley, Luna Dias, Maia Herzog, Lowry, unpublished data). Of these, the former two species are the primary vectors in Brazil and Ecuador respectively and are responsible for rapid increases in prevalence rates of onchocerciasis. An additional factor of future significance is the construction of a hydroelectric dam on the R. Tocantins at Serra da Mesa near Minaçu. The effect of this dam on the breeding grounds of potential vector species, and hence on the rate of transmission of onchocerciasis in the area, requires immediate investigation. The danger of relaxed vigilance over the entry of visitors to the Amazonia focus in terms of disease dispersal, especially in the light of the finding at Minaçu, has been highlighted (Moraes, 1991; Shelley, 1988; Shelley *et al.*, 1987b). The recent invasion of Yanomami territory by tens of thousands of tin and gold miners, and their subsequent dispersal to other parts of Brazil now greatly increases the possibility of the establishment of new foci in non endemic areas.

Measures are currently being initiated in Brazil by the Ministry of Health to provide more data on onchocerciasis in the two Brazilian foci and its potential dispersal, so that control measures can be used where there is a real prospect of success. In the Amazonia focus, prevalence rates and skin microfilarial densities are being measured to provide information on the current onchocerciasis situation, and a plan for ivermectin treatment of infected individuals has been introduced. Vector studies currently underway will need to obtain the basic data necessary for estimating the annual transmission potentials of vectors so that their relative importance may be confirmed and the effects of parasite control monitored. The difficulty of carrying out long term treatment of the Yanomamis is great, and control of the disease and its transmission based on data from the 1970s would centre on highland localities and involve both ivermectin treatment of infected individuals and vector control if feasible once the breeding grounds of *S. guianense* have been located (Shelley, 1991). At Minaçu studies will centre on providing baseline data on disease prevalence rates using the sensitive serological technique; vector species incrimination, distribution, biology and control; and the effect of the Serra da Mesa dam on the vector. Two angles are currently being researched in studies on the dispersal of the disease. Individuals (particularly miners, military personnel and FUNAI workers) who have visited the Amazonia focus will be tested for onchocerciasis using the serological technique. The distribution of anthropophilic simuliid species in Brazil is still being studied. The simuliid fauna and its distribution in Brazil are still incompletely known but certain areas are notorious for the high blackfly biting rates. Particular vigilance will be needed in areas where known vector species with unarmed cibaria, such as *S. guianense* and *S. exiguum s.l.*, occur. Cytological studies to discriminate the cytoforms of these two species in Brazil together with studies on their biology and vectorial importance and the development of methods for identifying cytoforms in adult females are required. The occurrence of *S. pertinax* in large numbers in south-east and southern Brazil needs investigation because it is a common man-biter that often occurs in enormous numbers, but its capacity to host *O. volvulus* has not yet been determined.

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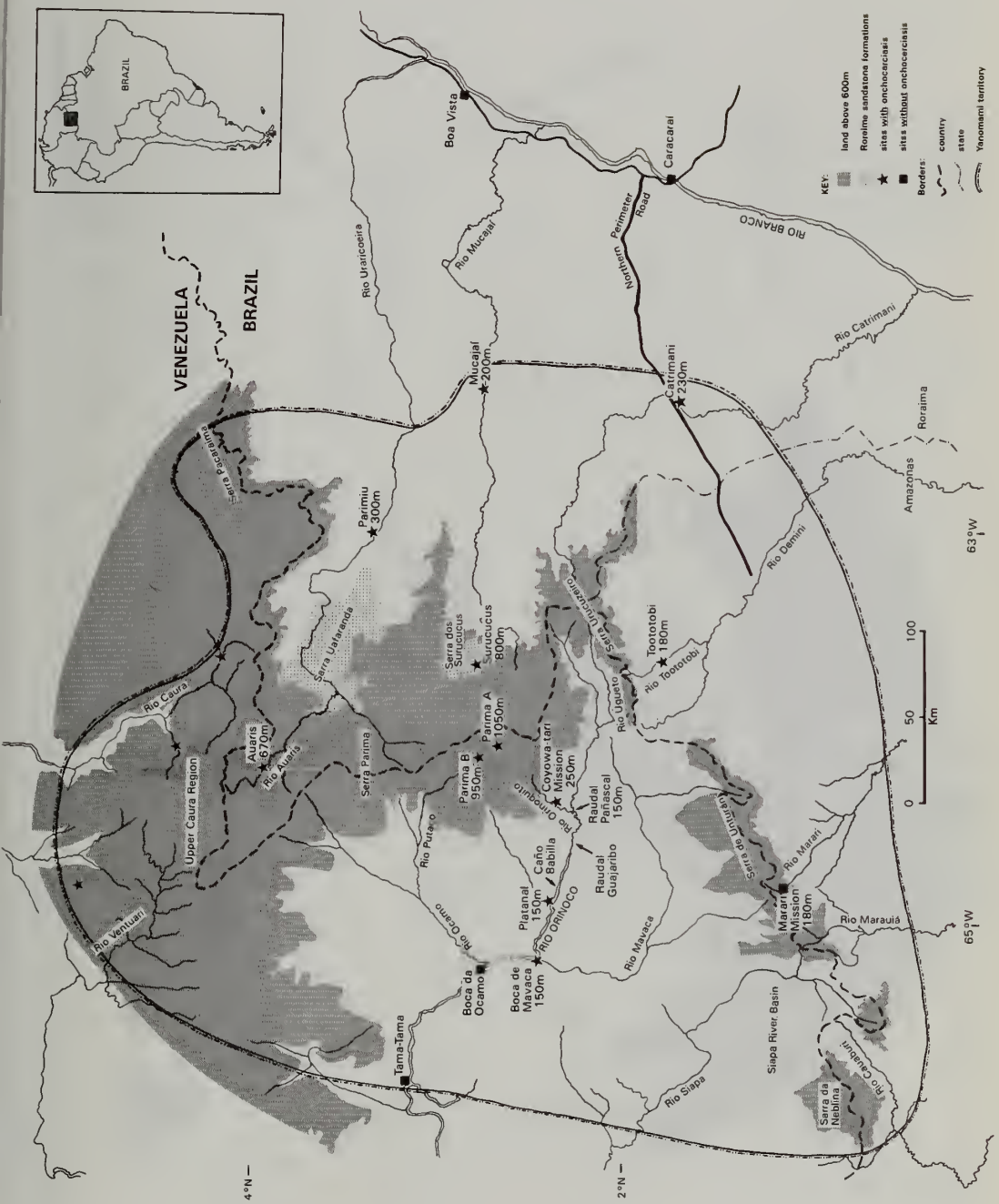
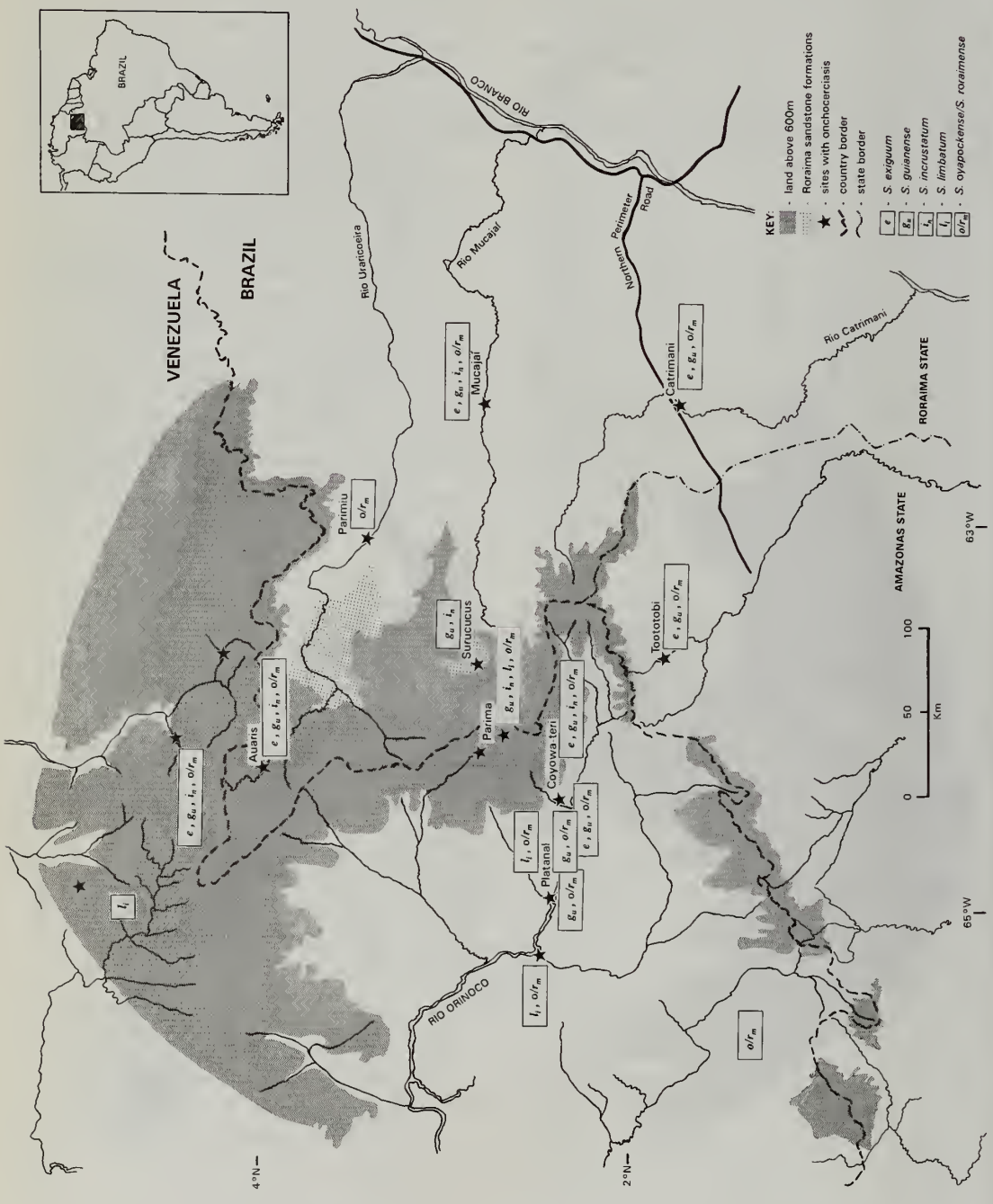
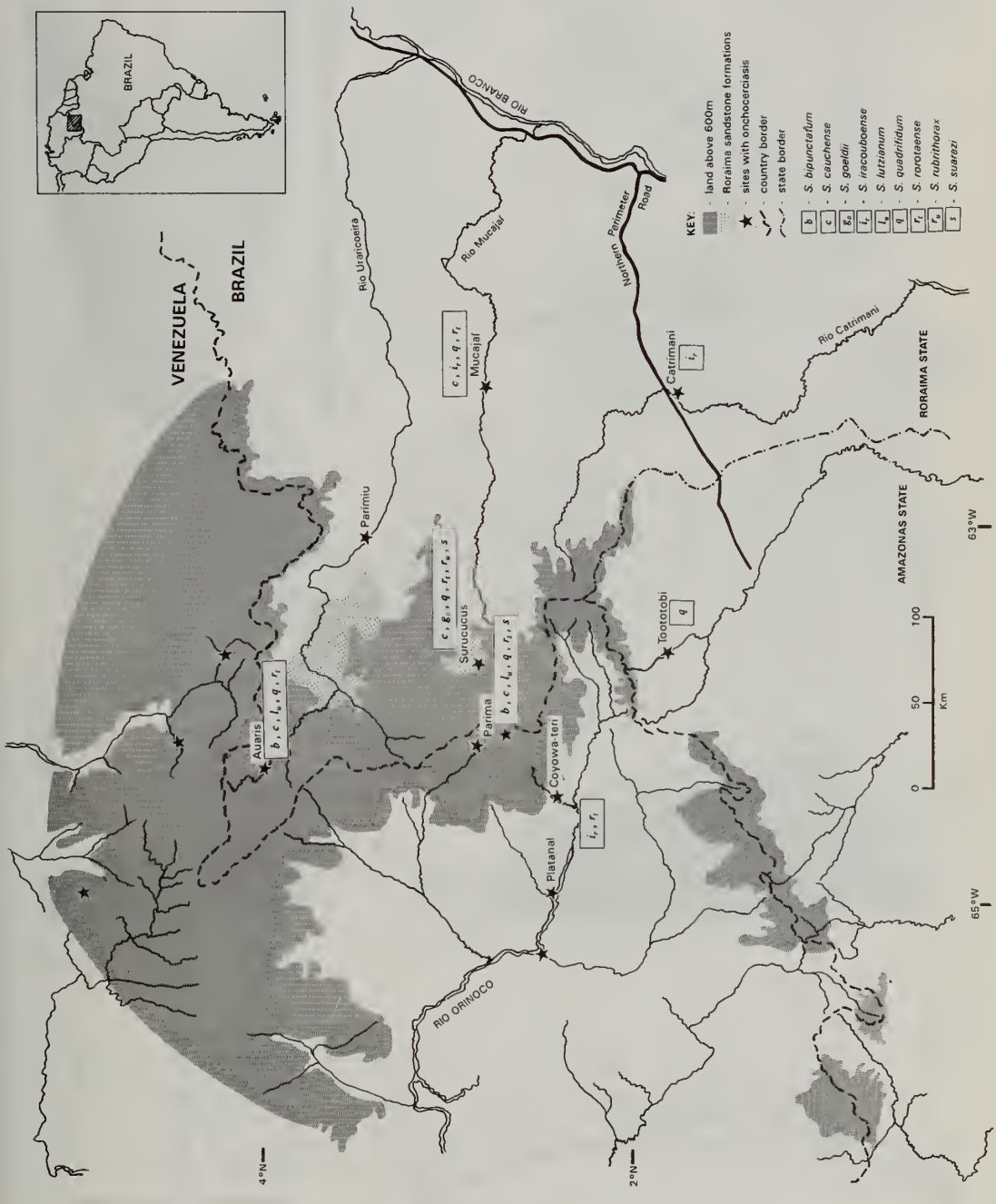


Map 1 The Amazonia onchocerciasis focus.



Map 2 Distribution of principal man-biting simuliid species in the Amazonia focus.



Map 3 Distribution of principal zoophilic simuliid species in the Amazonia focus.

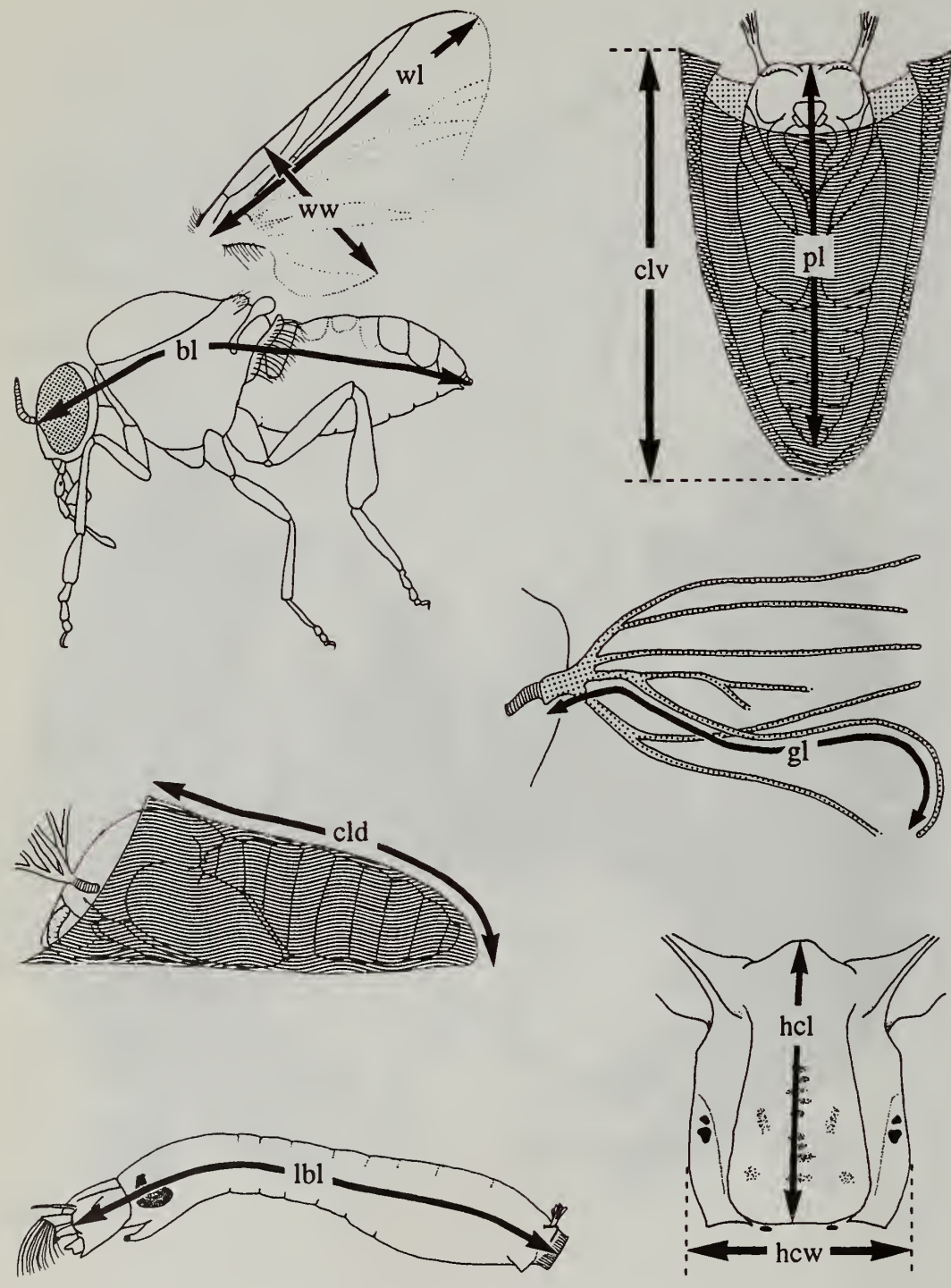
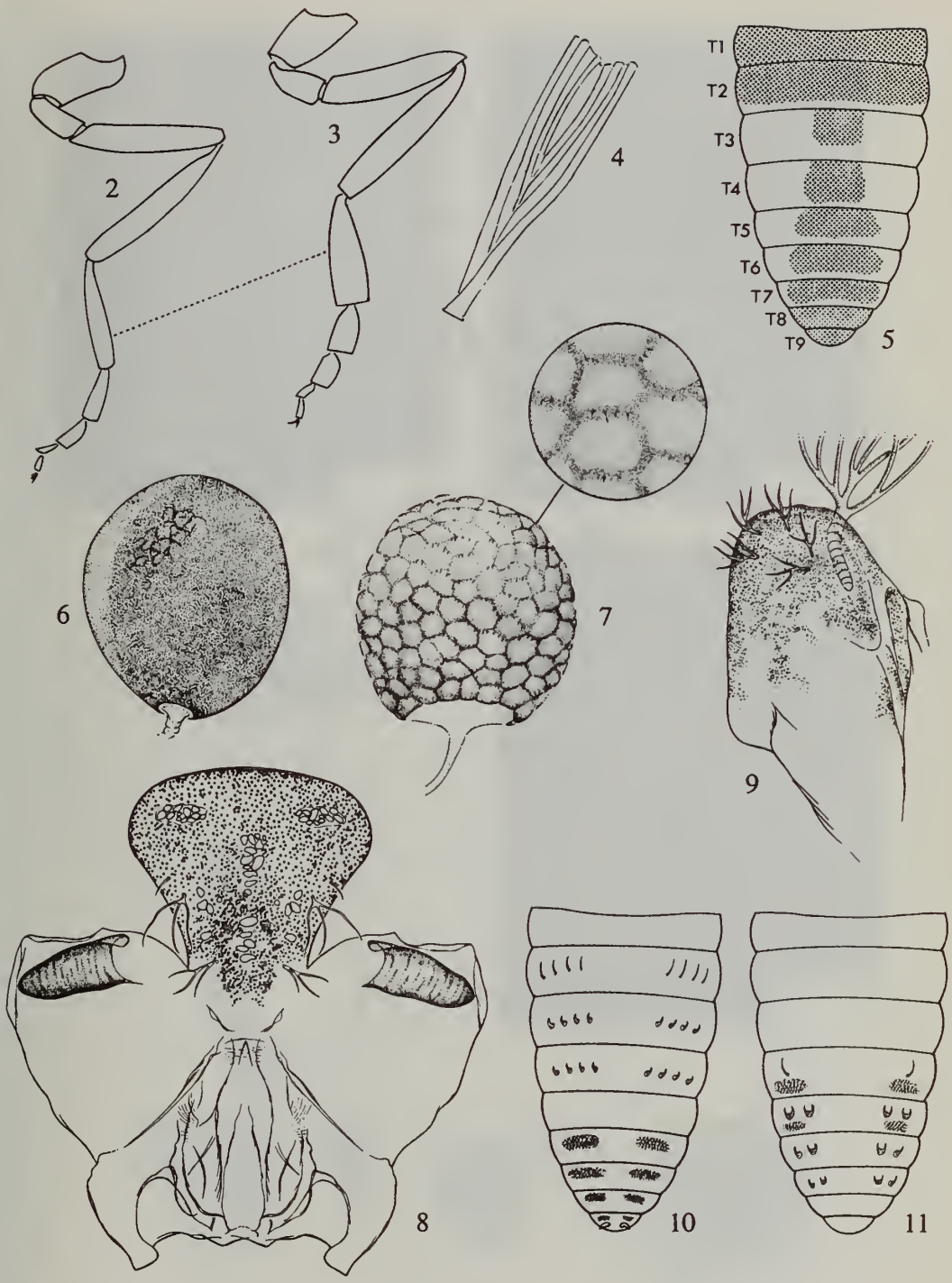


Fig. 1 Measurements made in adults, pupae and larvae. Adults: bl=body length, wl=wing length, ww=wing width; pupae: cld=cocoon length dorsally, clv=cocoon length ventrally, pl=pupa length, gl=gill length; larvae: lbl=larva body length, hcl=head capsule length, hcw=head capsule width. [Adapted from Crosskey, 1990.]



Figs 2–11 2, fore leg of *S. exiguum* showing narrow tarsi; 3, fore leg of *S. guianense* showing wide tarsi; 4, scale of leg of female *S. exiguum*; 5, dorsal view of abdomen of female *S. exiguum* showing well developed tergal plates; 6, spermatheca of female *S. exiguum*; 7, spermatheca of *S. guianense*; 8, frontoclypeus of female pupa of *S. exiguum*; 9, thorax of *S. exiguum* pupa; 10, dorsal view of pupal abdomen of *S. exiguum* showing chaetotaxy; 11, ventral view of pupal abdomen of *S. exiguum* showing chaetotaxy.

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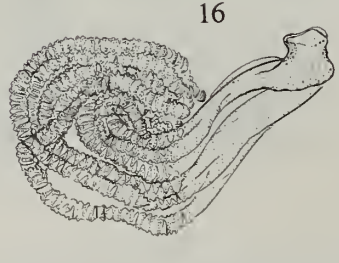

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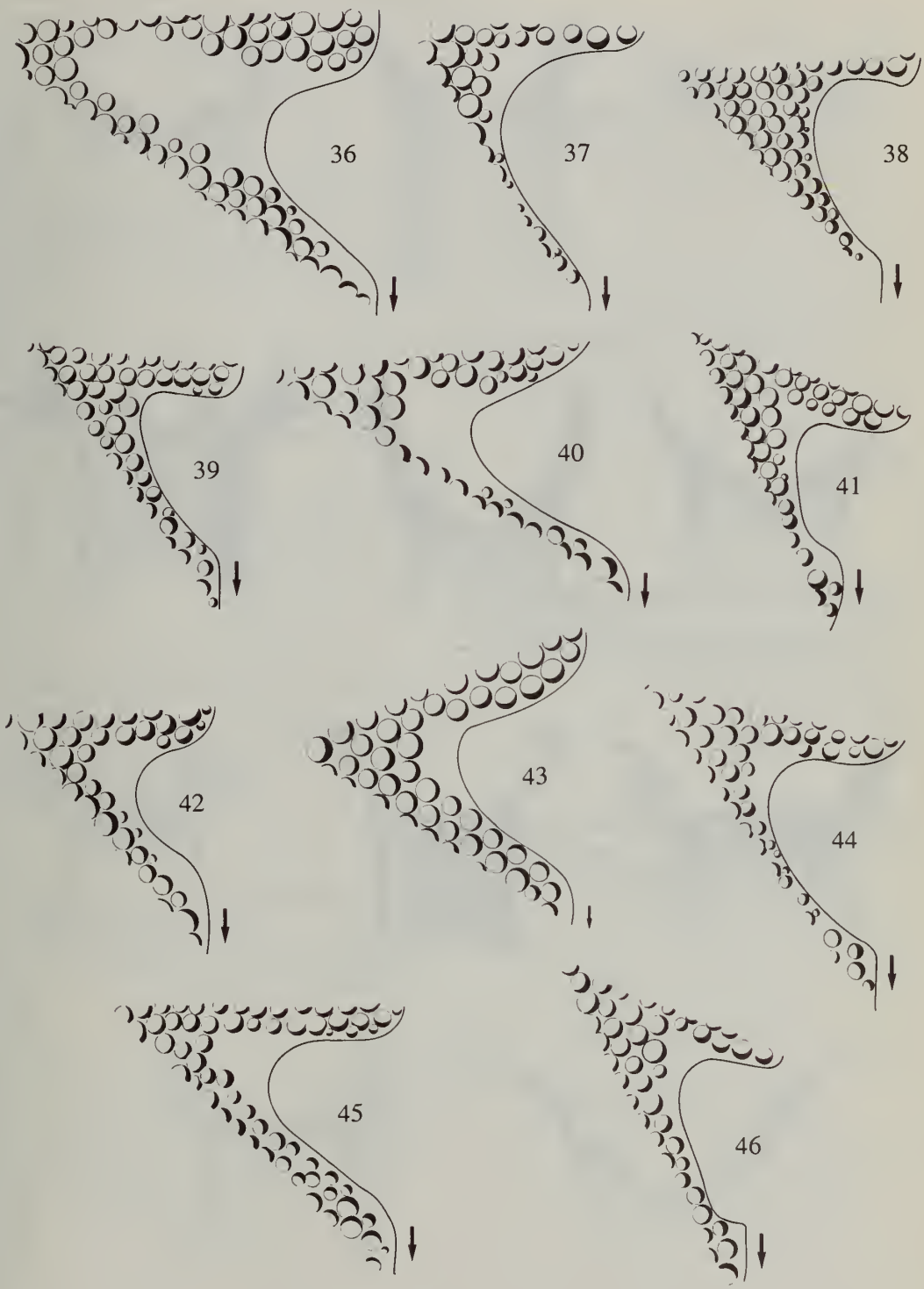
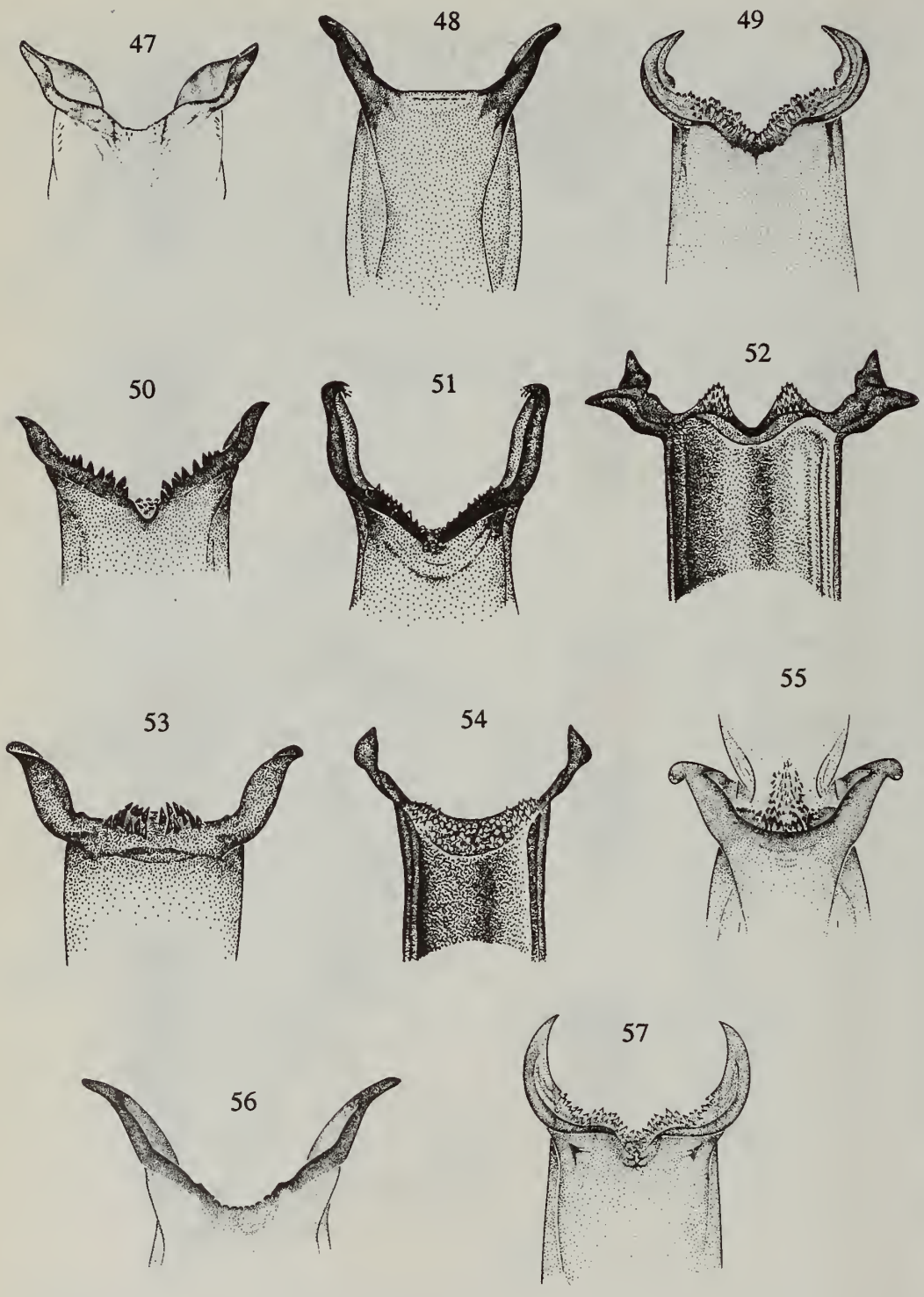
Figs 12–17 12, SEM of dorsal setae of *S. exiguum* larva; 13, SEM of dorsal setae of *S. incrustatum* larva; 14, SEM of dorsal setae of *S. guianense* larva; 15, proleg of larva of *S. guianense* showing plates and processes; 16, gill histoblast of *S. exiguum*; 17, anal gill of *S. exiguum* larva.

Colour Plate 1, Figs 18–26 Colour patterns of the female thorax, abdomen and legs of: 18, *S. rubrithorax*, anterior illumination; 19, *S. rubrithorax*, posterior illumination of thorax; 20, *S. exiguum*; 21, *S. quadrifidum*; 22, *S. cauchense*; 23, *S. oyapockense*, anterior illumination; 24, *S. oyapockense*, posterior illumination of thorax; 25, *S. oyapockense*, anterior illumination of thorax, (Ituxi); 26, *S. amazonicum*, anterior illumination of thorax, (Ituxi).

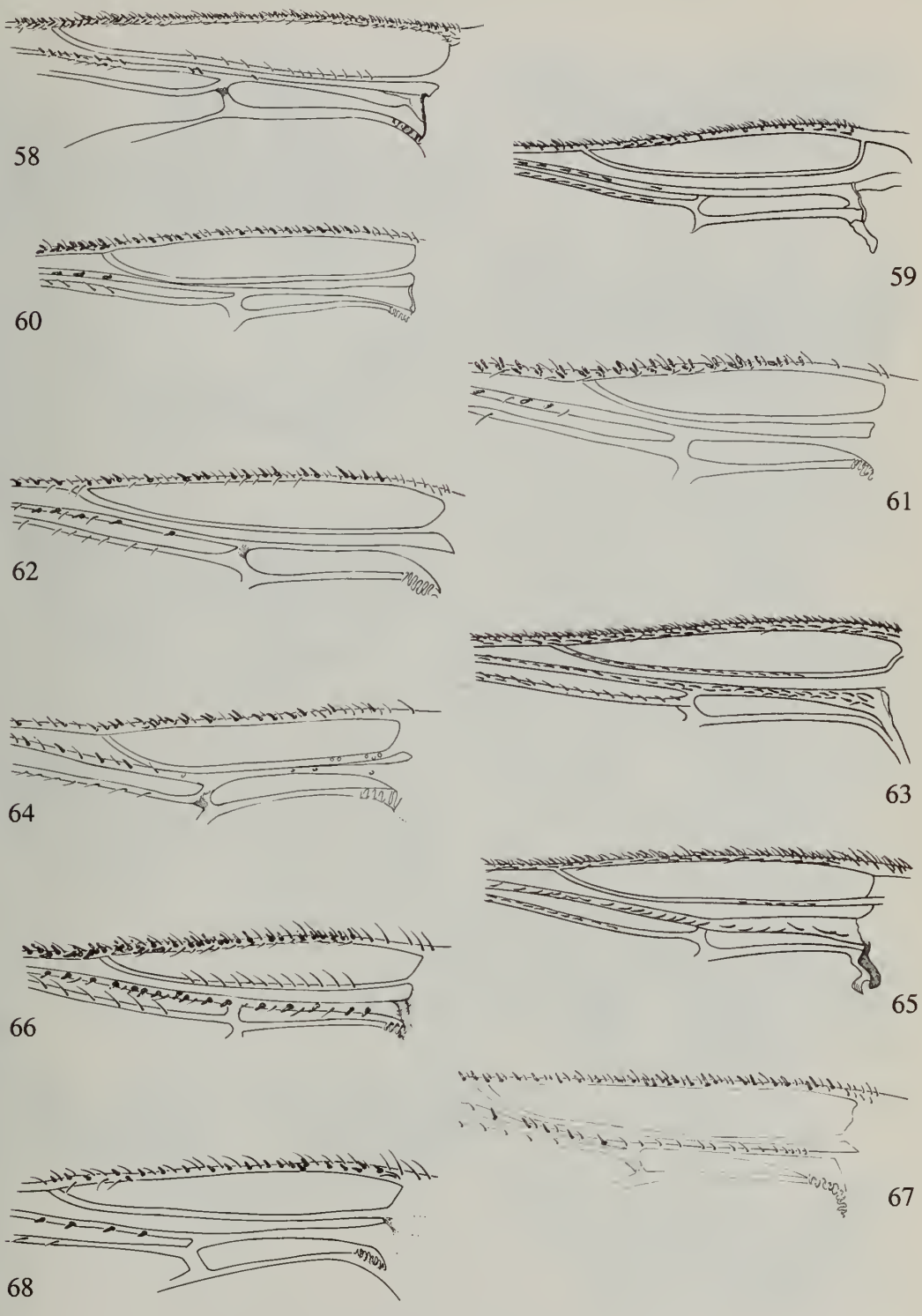
Colour Plate 2, Figs 27–35 Colour patterns of the female thorax, abdomen and legs of: 27, *S. incrustatum*; 28, *S. limbatum*, anterior illumination of thorax; 29, *S. limbatum*, posterior illumination of thorax; 30, *S. bipunctatum*; 31, *S. iracouboense*; 32, *S. lutzianum*; 33, *S. rorotaense*; 34, *S. guianense*; 35, *S. goeldii*.



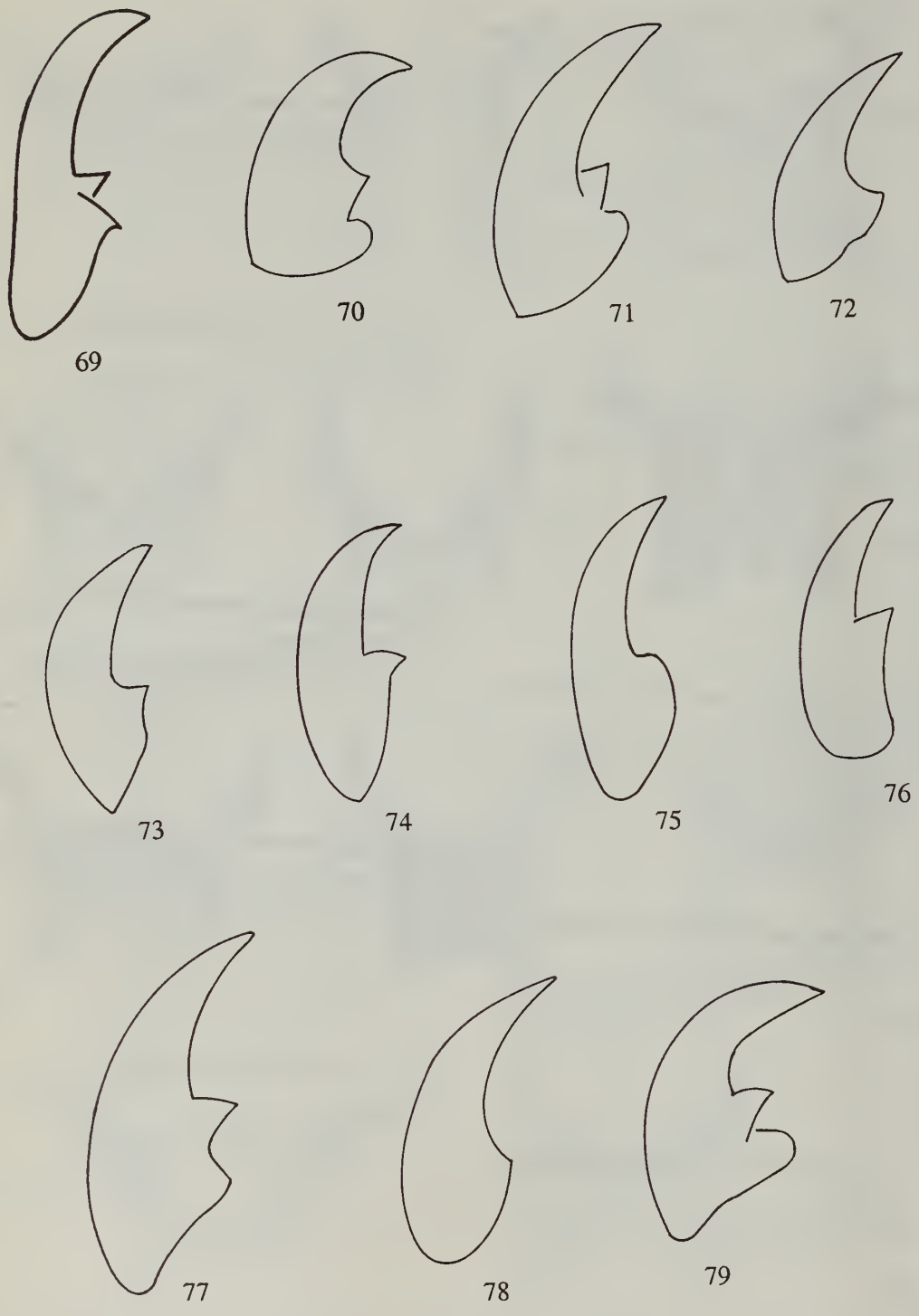
Figs 36–46 Nudiocular area of: 36, *S. rubrithorax*; 37, *S. exiguum*; 38, *S. quadrifidium*; 39, *S. oyapockense* ; 40, *S. incrustatum*; 41, *S. bipunctatum*; 42, *S. iracouboense*; 43, *S. lutzianum*; 44, *S. rorotaense*; 45, *S. guianense*; 46, *S. goeldii*.



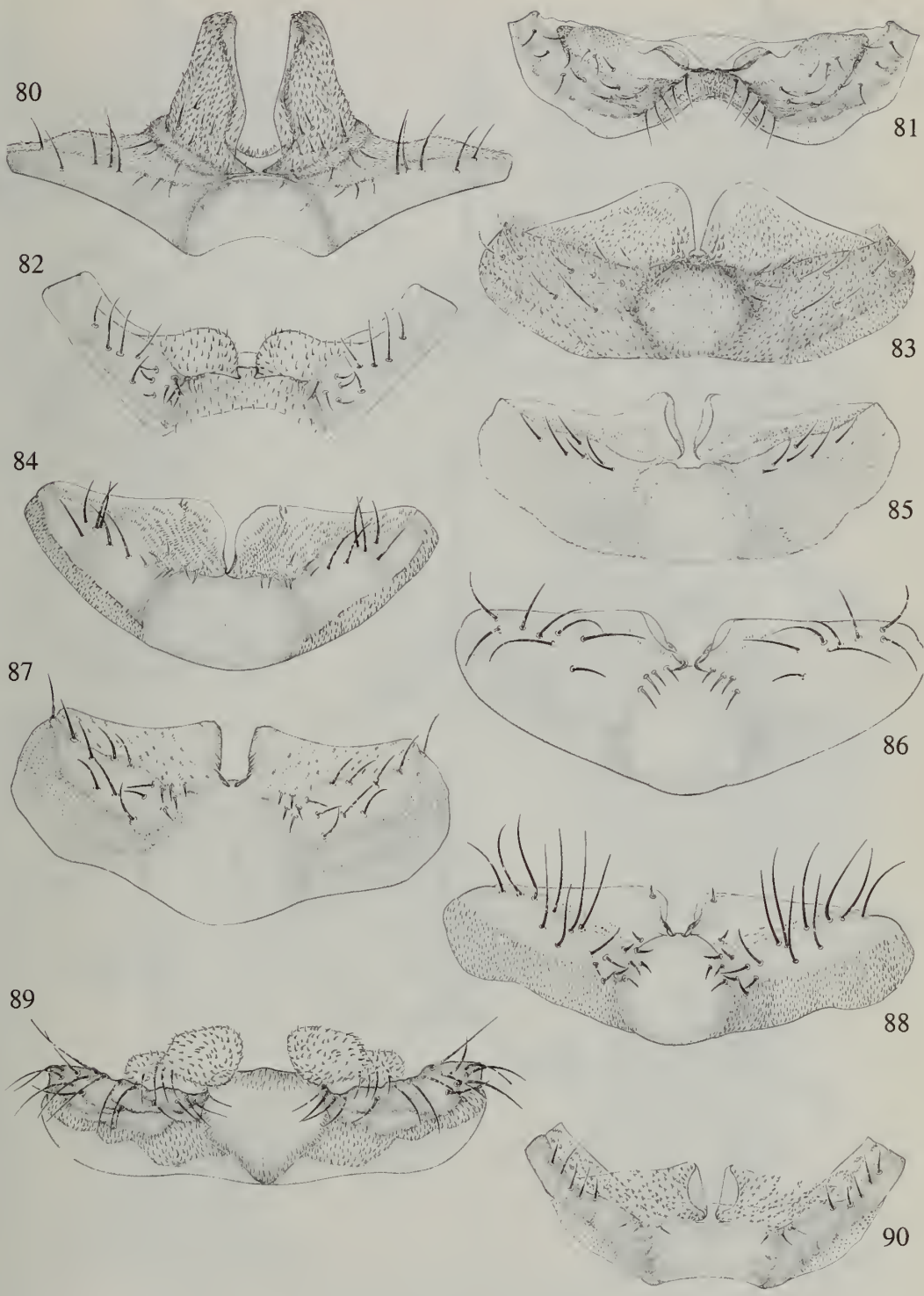
Figs 47–57 Cibarium of: 47, *S. rubrithorax*; 48, *S. exiguum*; 49, *S. quadrifidum*; 50, *S. oyapockense* ; 51, *S. incrustatum*; 52, *S. bipunctatum*; 53, *S. iracoubоense*; 54, *S. lutzianum*; 55, *S. rorotaense*; 56, *S. guianense*; 57, *S. goeldii*.



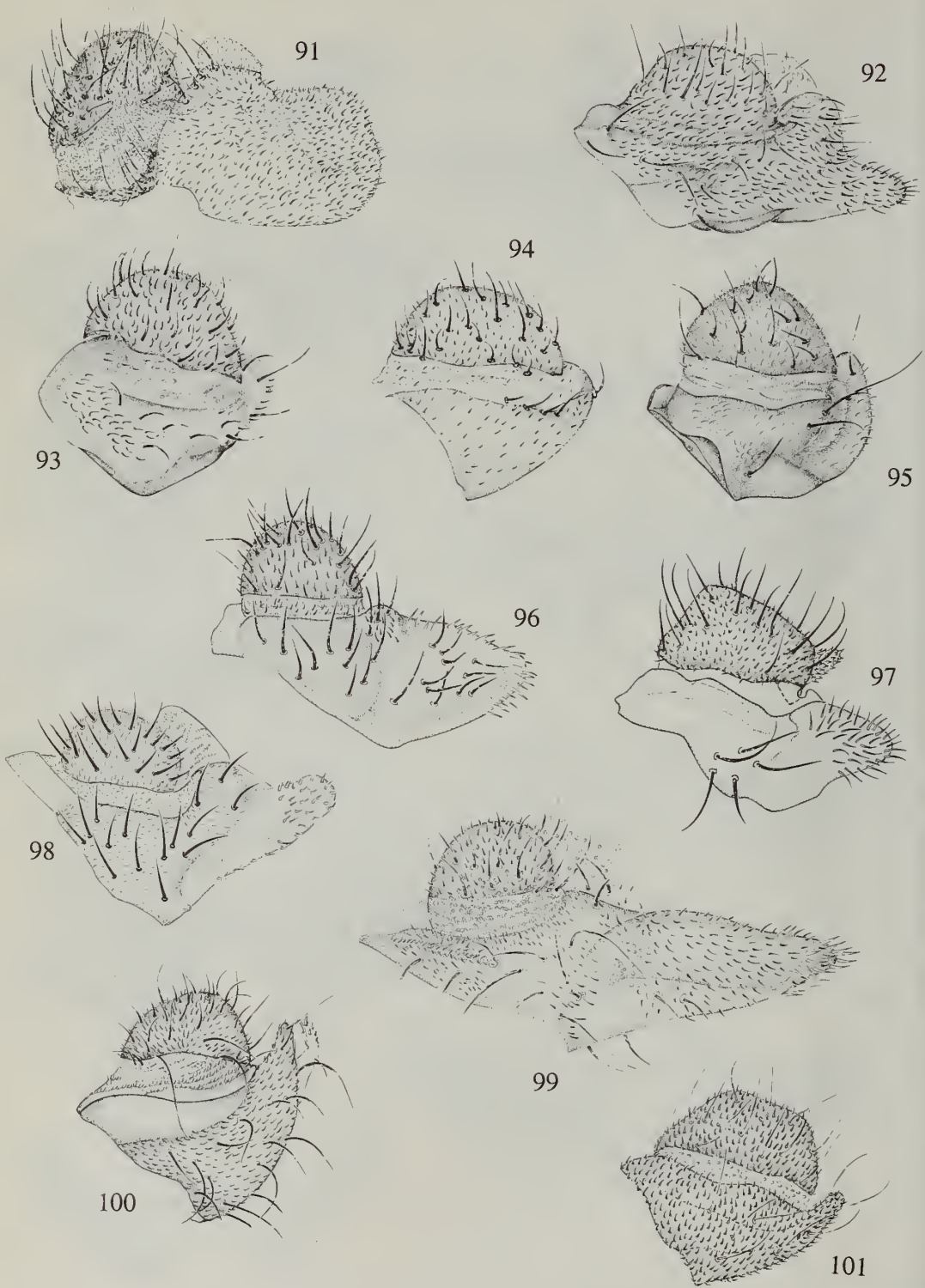
Figs 58–68 Anterior wing veins of female: 58, *S. rubrithorax*; 59, *S. exiguum*; 60, *S. quadrifidum*; 61, *S. oyapockense* ; 62, *S. incrustatum*; 63, *S. bipunctatum*; 64, *S. iracouboense*; 65, *S. lutzianum*; 66, *S. rorotaense*; 67, *S. guianense*; 68, *S. goeldii*.



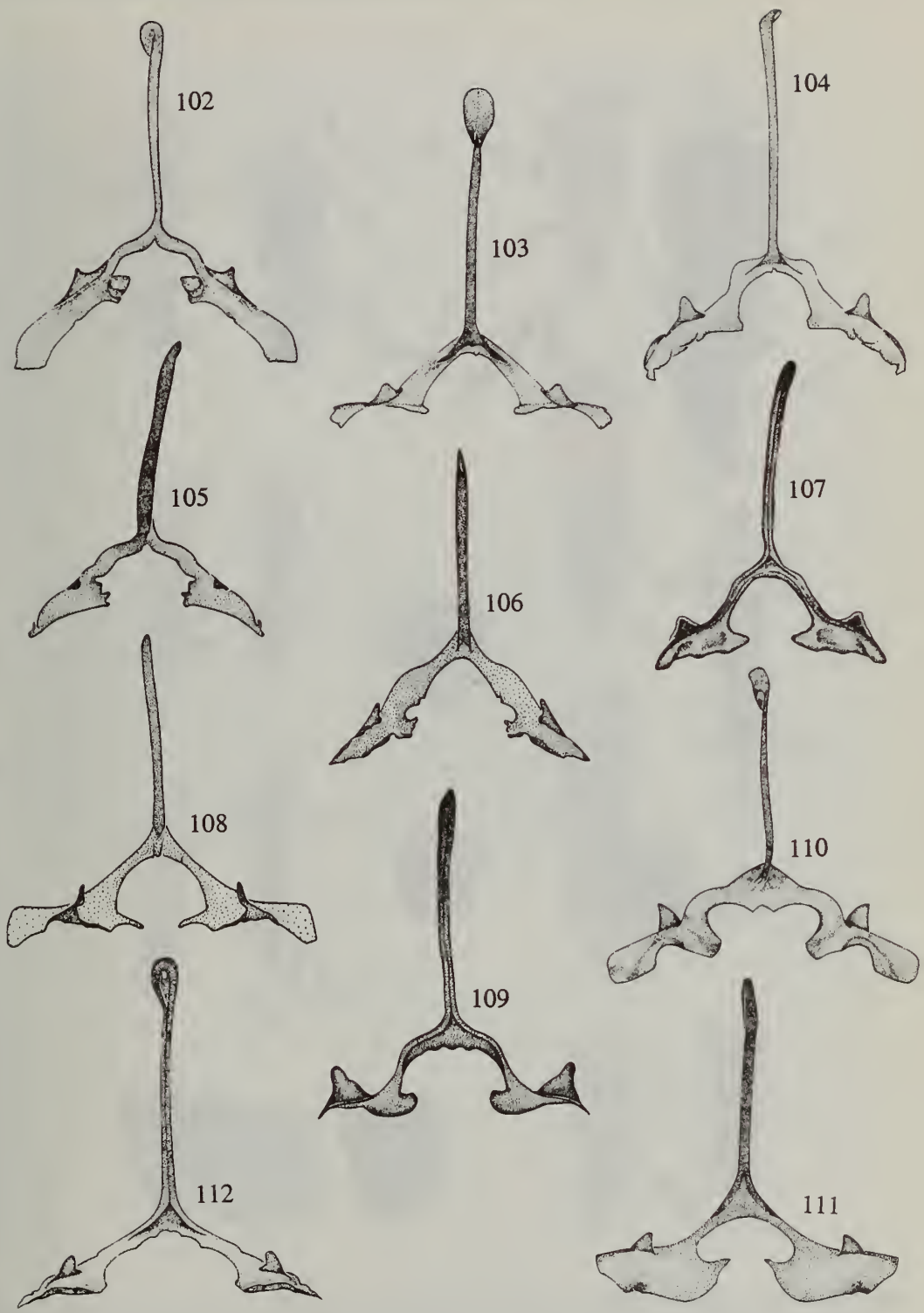
Figs 69–79 Claws of female: 69, *S. rubrithorax*; 70, *S. exiguum*; 71, *S. quadrifidum*; 72, *S. oyapockense* ; 73, *S. incrustatum*; 74, *S. bipunctatum*; 75, *S. iracouboense*; 76, *S. lutzianum*; 77, *S. rorotaense*; 78, *S. guianense*; 79, *S. goeldii*.



Figs 80–90 Eighth sternite and gonopophyses of: 80, *S. rubrithorax*; 81, *S. exiguum*; 82, *S. quadrifidum*; 83, *S. oyapockense*; 84, *S. incrustatum*; 85, *S. bipunctatum*; 86, *S. iracouboense*; 87, *S. lutzianum*; 88, *S. rorotaense*; 89, *S. guianense*; 90, *S. goeldii*.

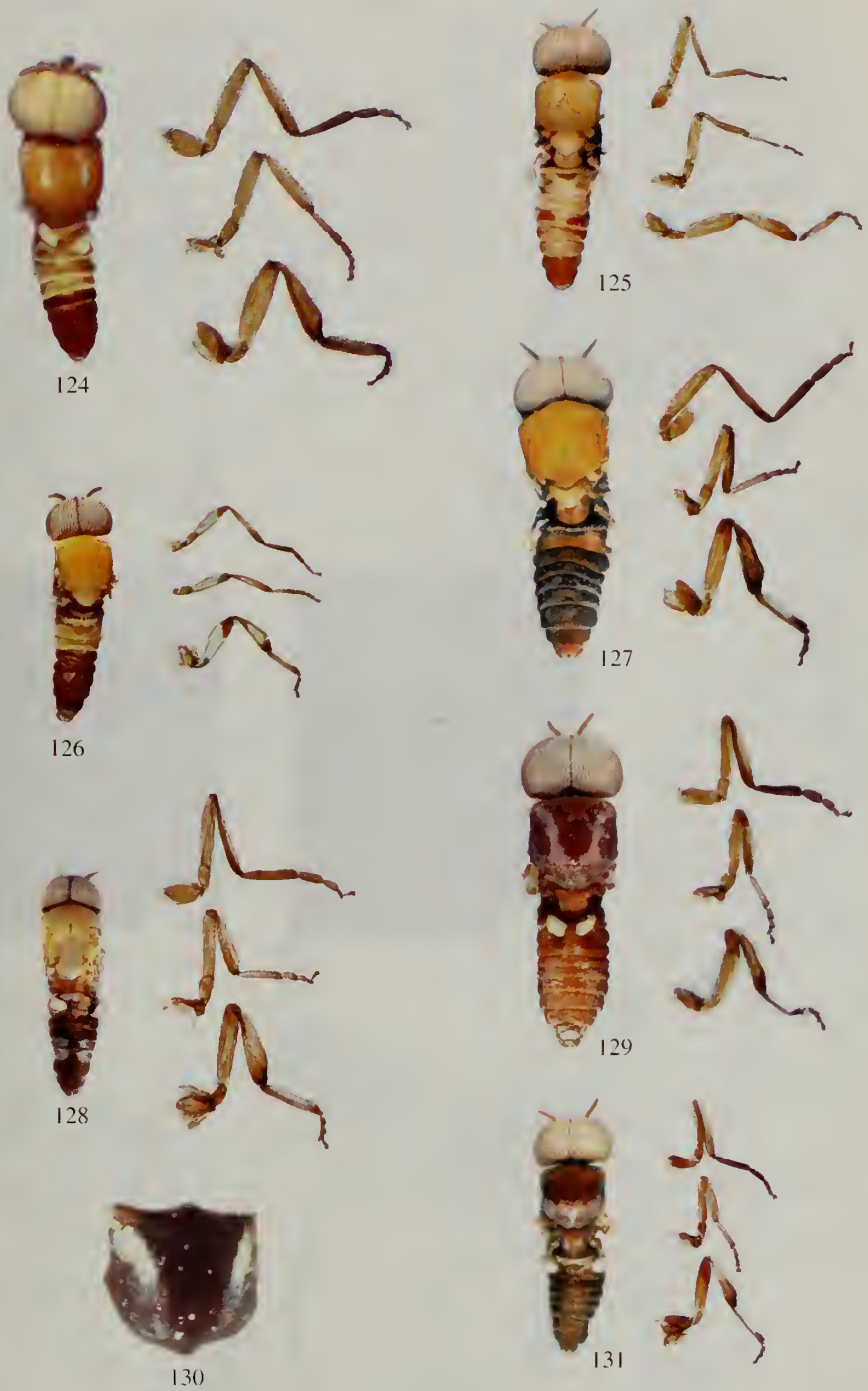


Figs 91–101 Cercus and paraproct of: 91, *S. rubrithorax*; 92, *S. exiguum*; 93, *S. quadrifidum*; 94, *S. oyapockense*; 95, *S. incrustatum*; 96, *S. bipunctatum*; 97, *S. iracouboense*; 98, *S. lutzianum*; 99, *S. rorotaense*; 100, *S. guianense*; 101, *S. goeldii*.

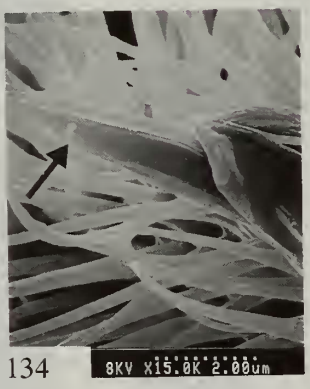


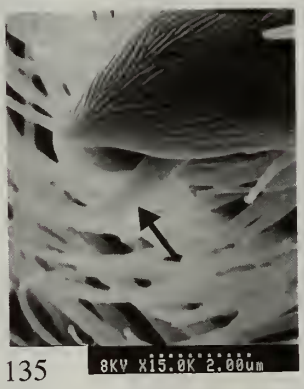
Figs 102–112 Genital fork of: 102, *S. rubrithorax*; 103, *S. exiguum*; 104, *S. quadrifidum*; 105, *S. oyapockense*; 106, *S. incrustatum*; 107, *S. bipunctatum*; 108, *S. iracouboense*; 109, *S. lutzianum*; 110, *S. rorotaense*; 111, *S. guianense*; 112, *S. goeldii*.

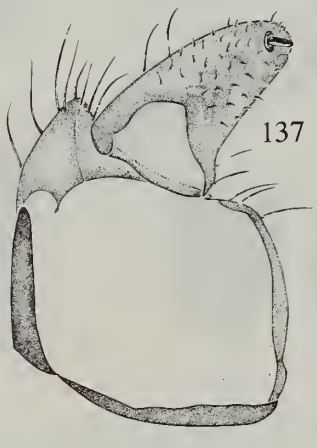
Colour Plate 3, Figs 113–123 Colour patterns of the male thorax, abdomen and legs of: 113, *S. rubrithorax*; 114, *S. exiguum*; 115, *S. quadrifidum*, with cunae on thorax; 116, *S. quadrifidum*, thorax without cunae; 117, *S. oyapockense*, Bem Querer; 118, *S. oyapockense*, thorax of specimen from R. Arraia; 119, *S. oyapockense*, thorax of specimen from Tootobi; 120, *S. roraimense*; 121, *S. incrustatum*; 122, *S. limbatum*, anterior illumination of thorax; 123, *S. limbatum*, posterior illumination of thorax.



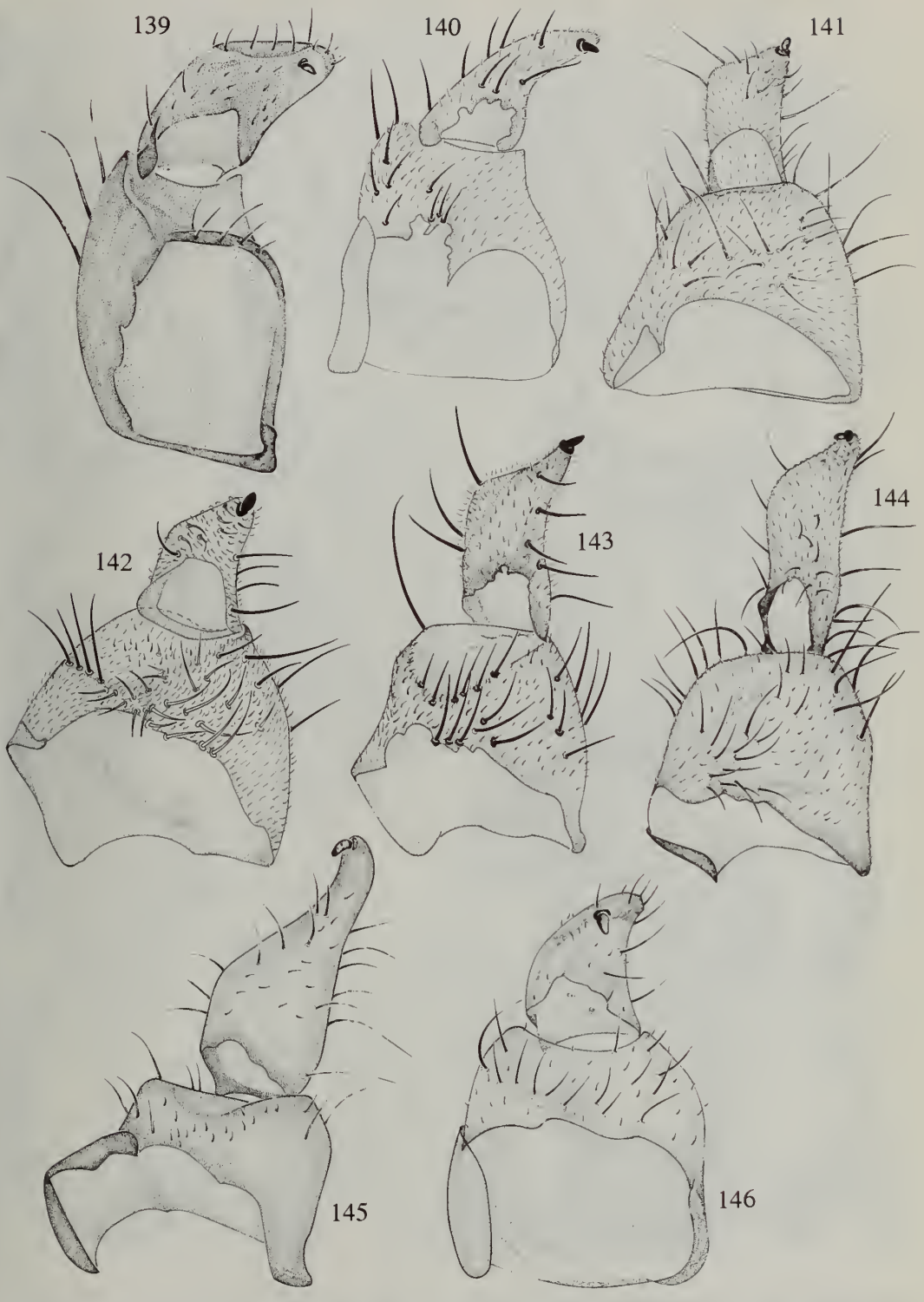
Colour Plate 4, Figs 124–131 Colour patterns of the male thorax, abdomen and legs of: 124, *S. bipunctatum*; 125, *S. iracouboense*; 126, *S. lutzianum*; 127, *S. rorotaense*; 128, *S. suarezi*; 129, *S. guianense*; 130, *S. guianense*, thorax of Tapajos form; 131, *S. goeldii*. (Note: silver pruinose patterns on abdominal segments only visible by varying angle of light illumination. Consult text for accurate description of number and extent of these patterns).



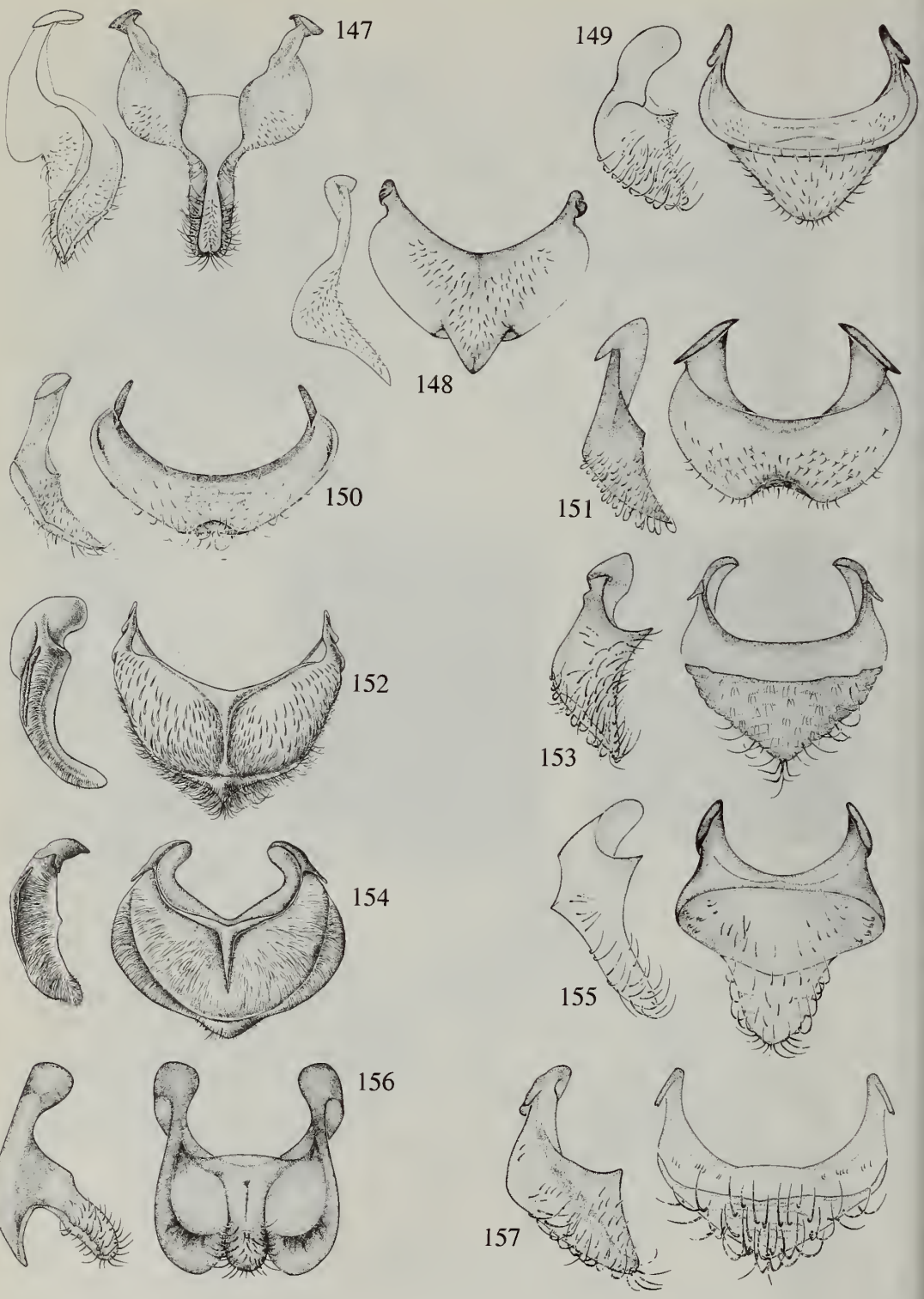




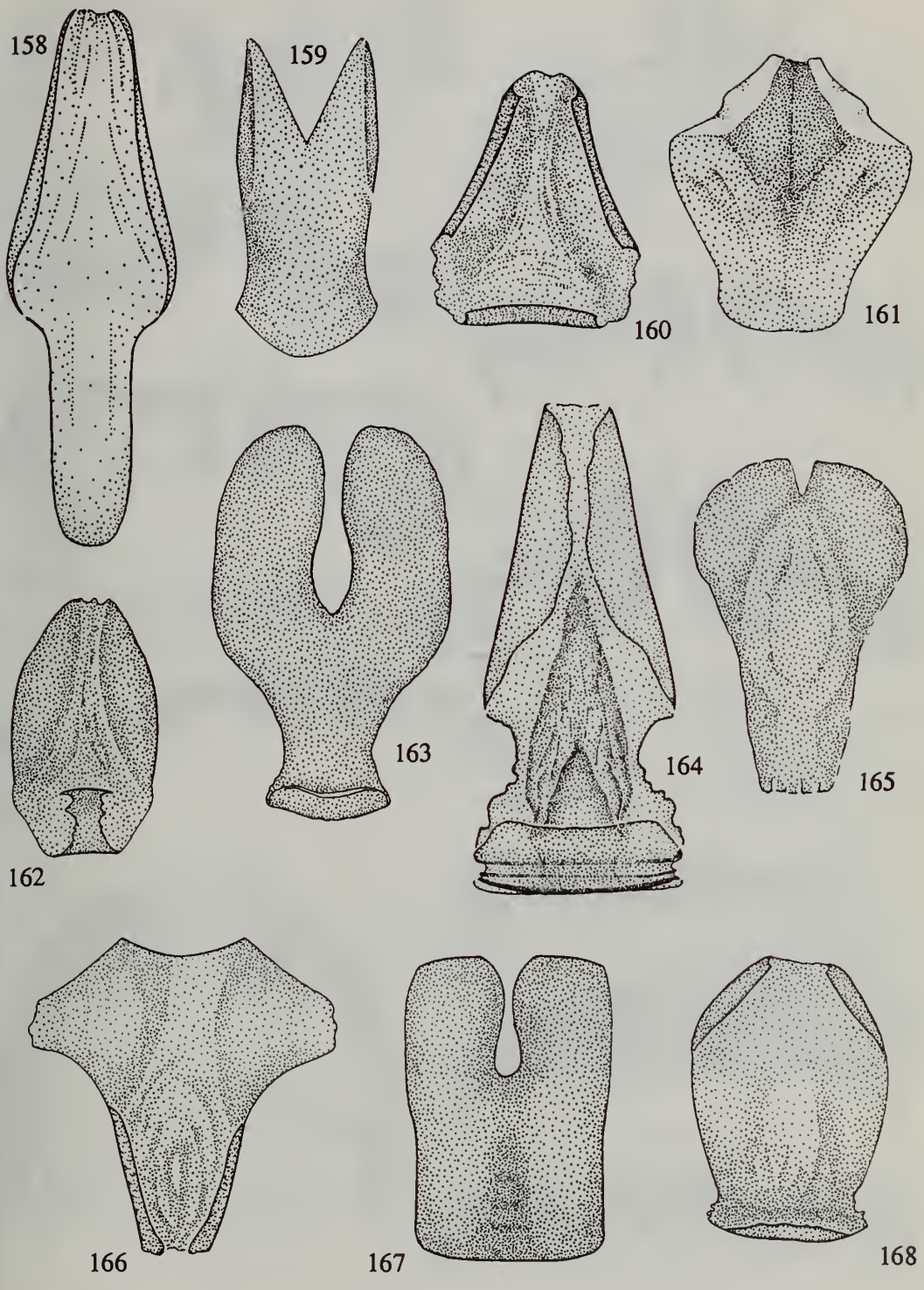
Figs 132–138 Gonocoxite and gonostyle of: 132, *S. rubrithorax*; 133, *S. exiguum*; 134, *S. exiguum* Catrimani, Brazil, SEM of distal part of gonostyle; 135, *S. exiguum* Ecuador, SEM of distal part of gonostyle; 136, *S. quadrifidum*; 137, *S. oyapockense*; 138, *S. roraimense*.



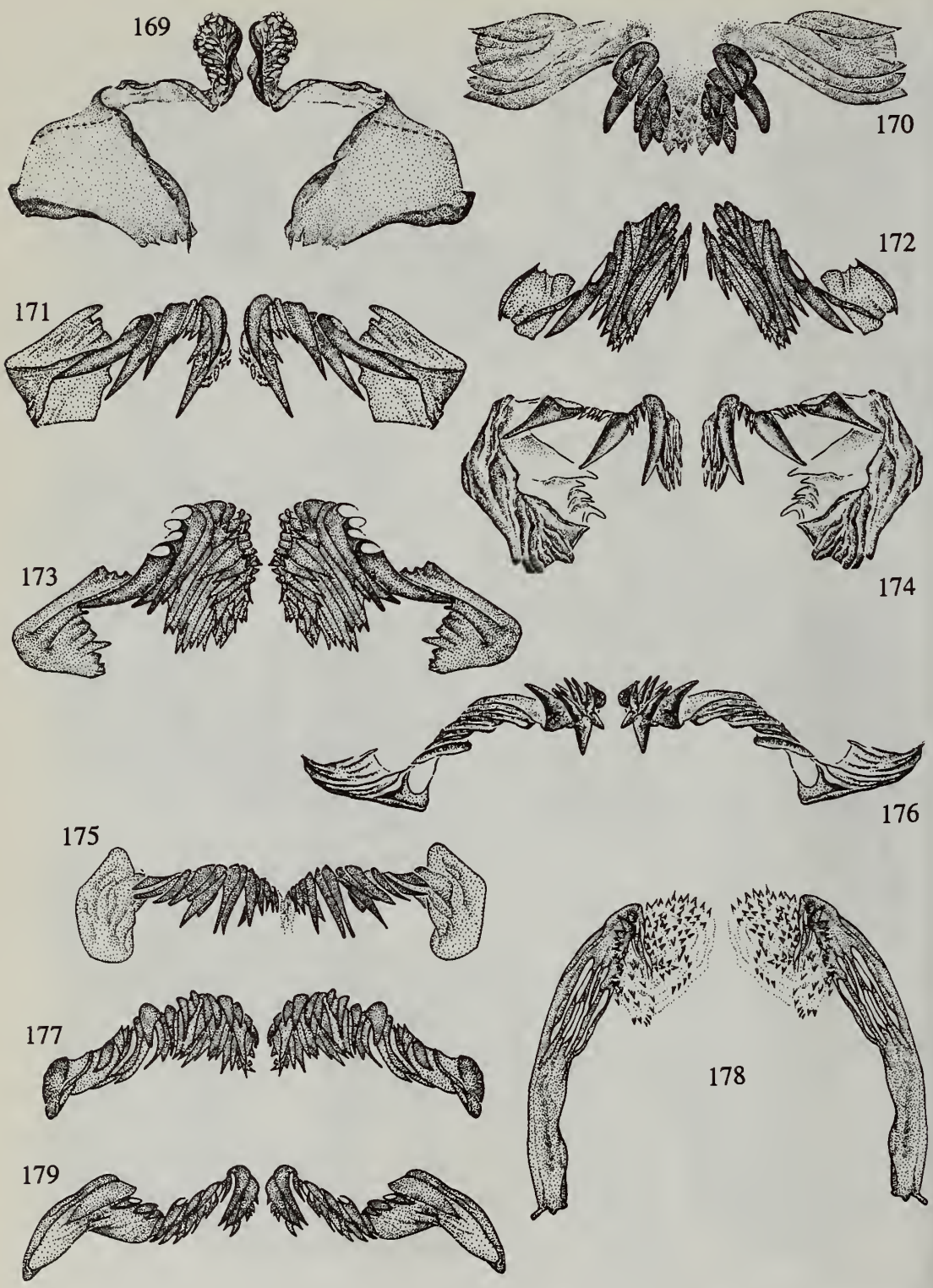
Figs 139–146 Gonocoxite and gonostyle of: 139, *S. incrustatum*; 140, *S. bipunctatum*; 141, *S. iracouboense*; 142, *S. samboni*; 143, *S. lutzianum*; 144, *S. rorotaense*; 145, *S. guianense*; 146, *S. goeldii*.



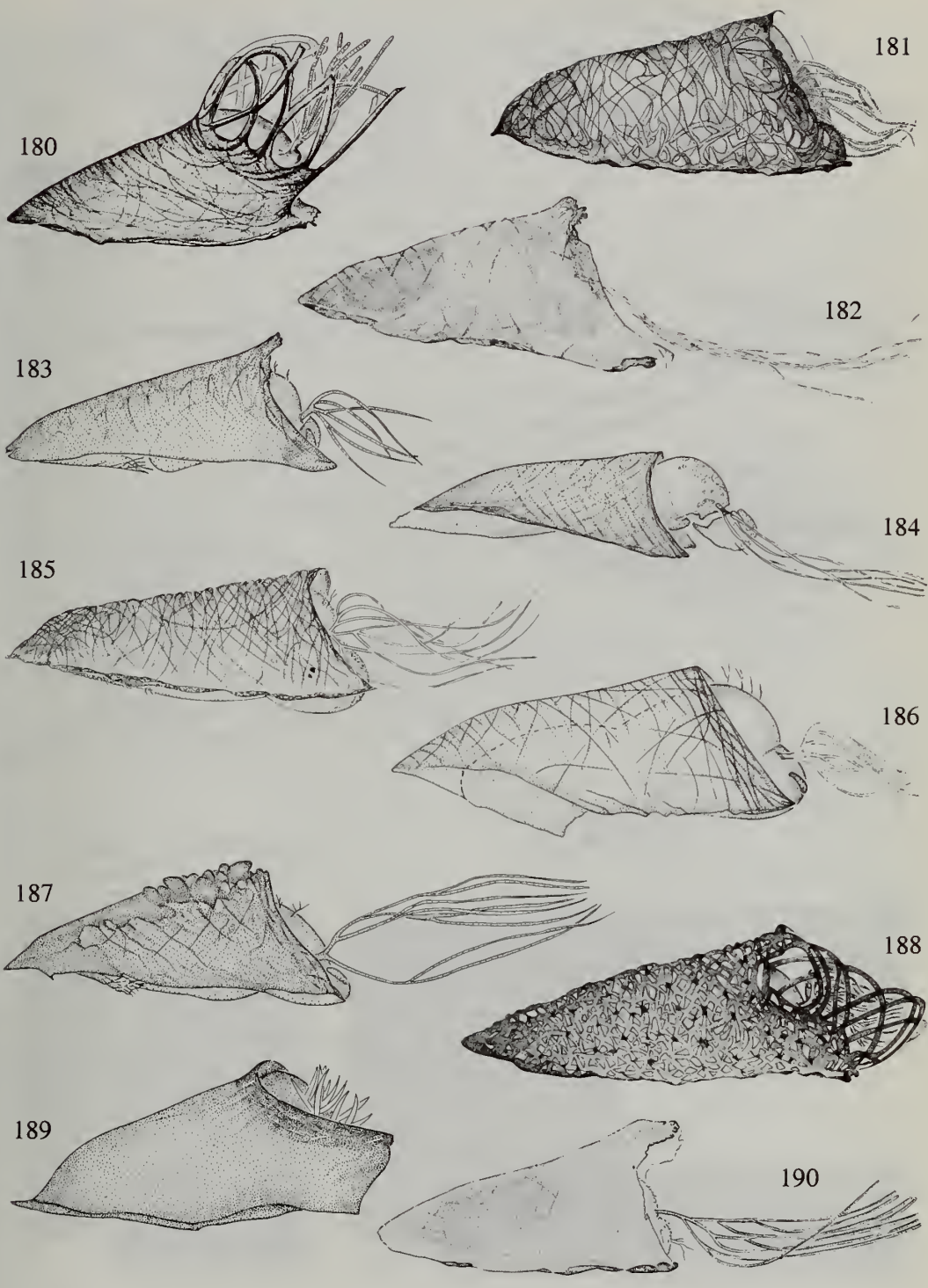
Figs 147–157 Ventral view and profile of ventral plates of: 147, *S. rubrithorax*; 148, *S. exiguum*; 149, *S. quadrifidum*; 150, *S. oyapockense*; 151, *S. incrustatum*; 152, *S. bipunctatum*; 153, *S. iracouboense*; 154, *S. lutzianum*; 155, *S. rorotaense*; 156,*S. guianense*; 157, *S. goeldii*.



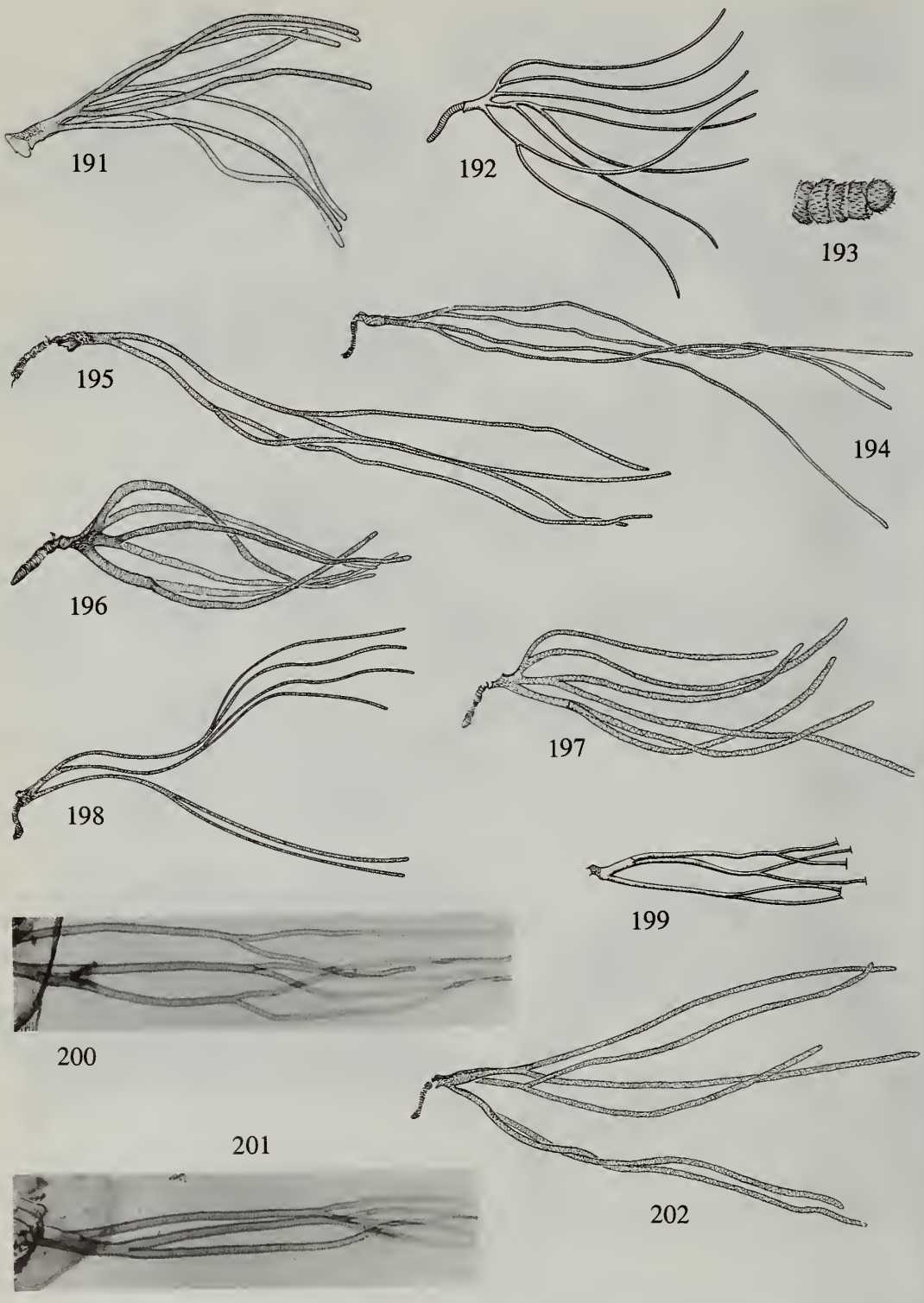
Figs 158–168 Median sclerites of: 158, *S. rubrithorax*; 159, *S. exiguum*; 160, *S. quadrifidum*; 161, *S. oyapockense*; 162,*S. incrustatum*; 163, *S. bipunctatum*; 164, *S. iracouboense*; 165, *S. lutzianum*; 166, *S. rorotaense*; 167, *S. guianense*; 168, *S. goeldii*.



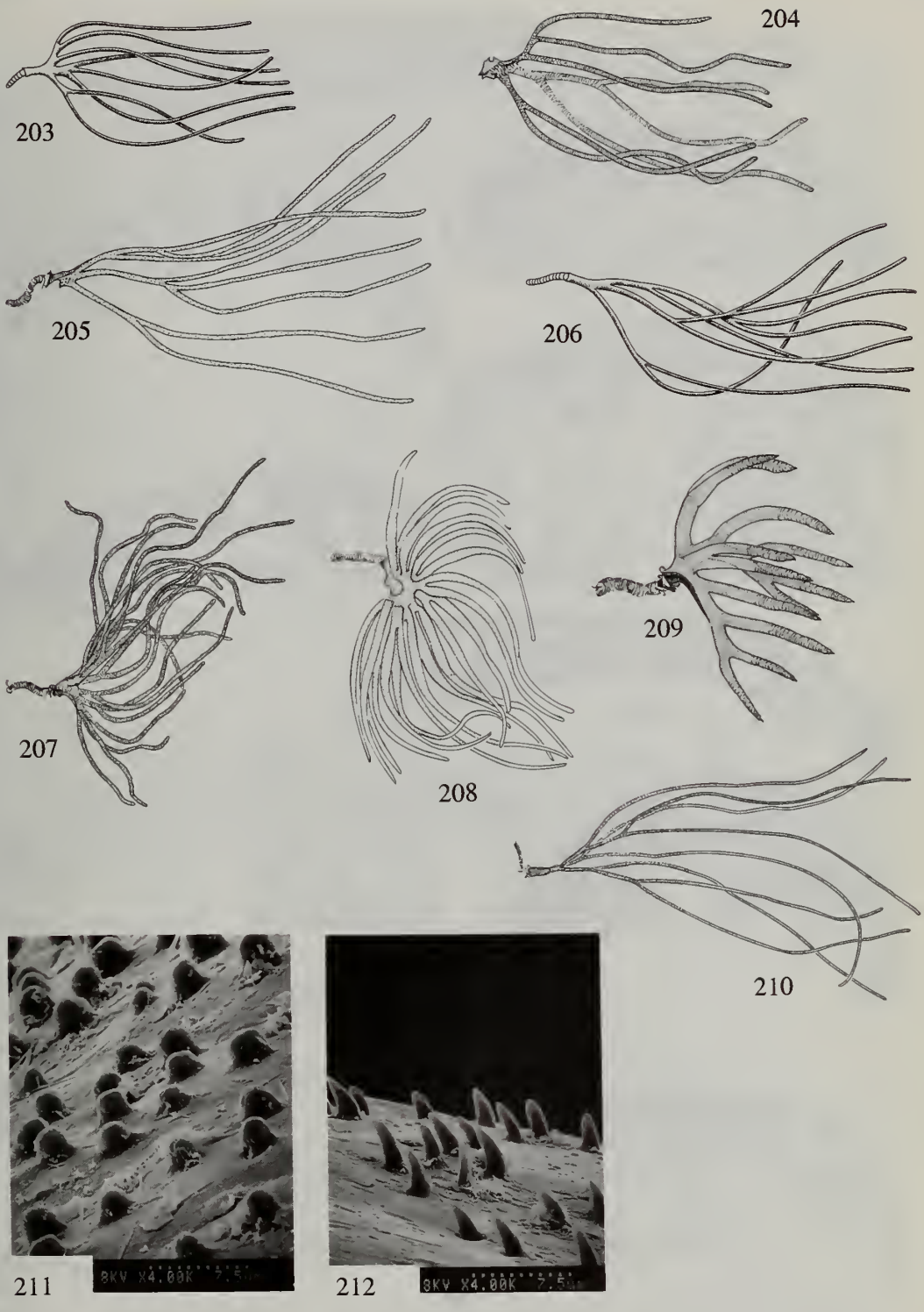
Figs 169–179 Parameres of: 169, *S. rubrithorax*; 170, *S. exiguum*; 171, *S. quadrifidum*; 172, *S. oyapockense*; 173, *S. incrustatum*; 174, *S. bipunctatum*; 175, *S. iracouboense*; 176, *S. lutzianum*; 177, *S. rorotaense*; 178, *S. guianense*; 179, *S. goeldii*.



Figs 180–190 Lateral view of pupa and cocoon of: 180, *S. rubrithorax*; 181, *S. exiguum*; 182, *S. quadrifidum*; 183, *S. oyapockense*; 184, *S. incrustatum*; 185, *S. bipunctatum*; 186, *S. iracouboense*; 187, *S. lutzianum*; 188, *S. rorotaense*; 189, *S. guianense*; 190, *S. goeldii*.

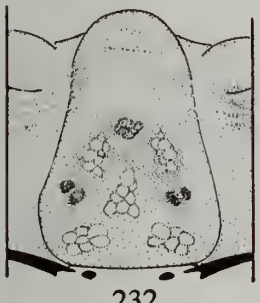


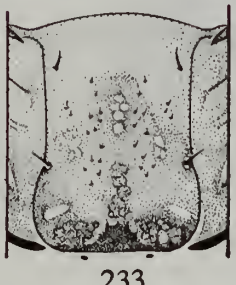
Figs 191–202 Pupal gill of: 191, *S. rubrithorax*; 192, *S. exiguum*; 193, *S. exiguum*, detail of filament; 194, *S. quadrifidum*; 195, *S. cauchense*; 196, *S. oyapockense*; 197, *S. roraimense*; 198, *S. incrustatum*; 199, *S. incrustatum* lectotype RHS; 200, *S. aequifurcatum* holotype LHS; 201, *S. aequifurcatum* holotype RHS; 202, *S. limbatum*.

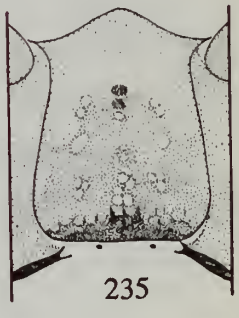


Figs 203–212 Pupal gill of: 203, *S. bipunctatum*; 204, *S. iracouboense*; 205, *S. samboni*; 206, *S. lutzianum*; 207, *S. rorotaense*; 208, *S. suarezi*; 209, *S. guianense*; 210, *S. goeldii*. Thorax of pupa showing platelets: 211, *S. oyapockense*; 212, *S. roraimense*.

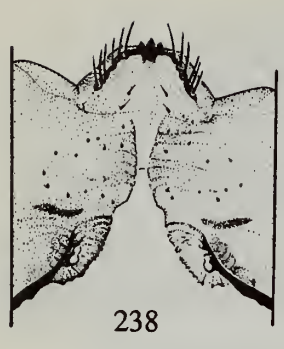
Figs 213–223 Lateral view of larva of: 213, *S. rubrithorax*; 214, *S. exiguum*; 215, *S. quadrifidum*; 216, *S. oyapockense*; 217, *S. incrustatum*; 218, *S. bipunctatum*; 219, *S. iracouboense*; 220, *S. lutzianum*; 221, *S. rorotaense*; 222, *S. guianense*; 223, *S. goeldii*.

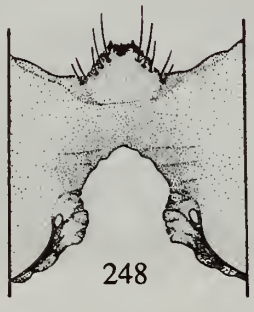




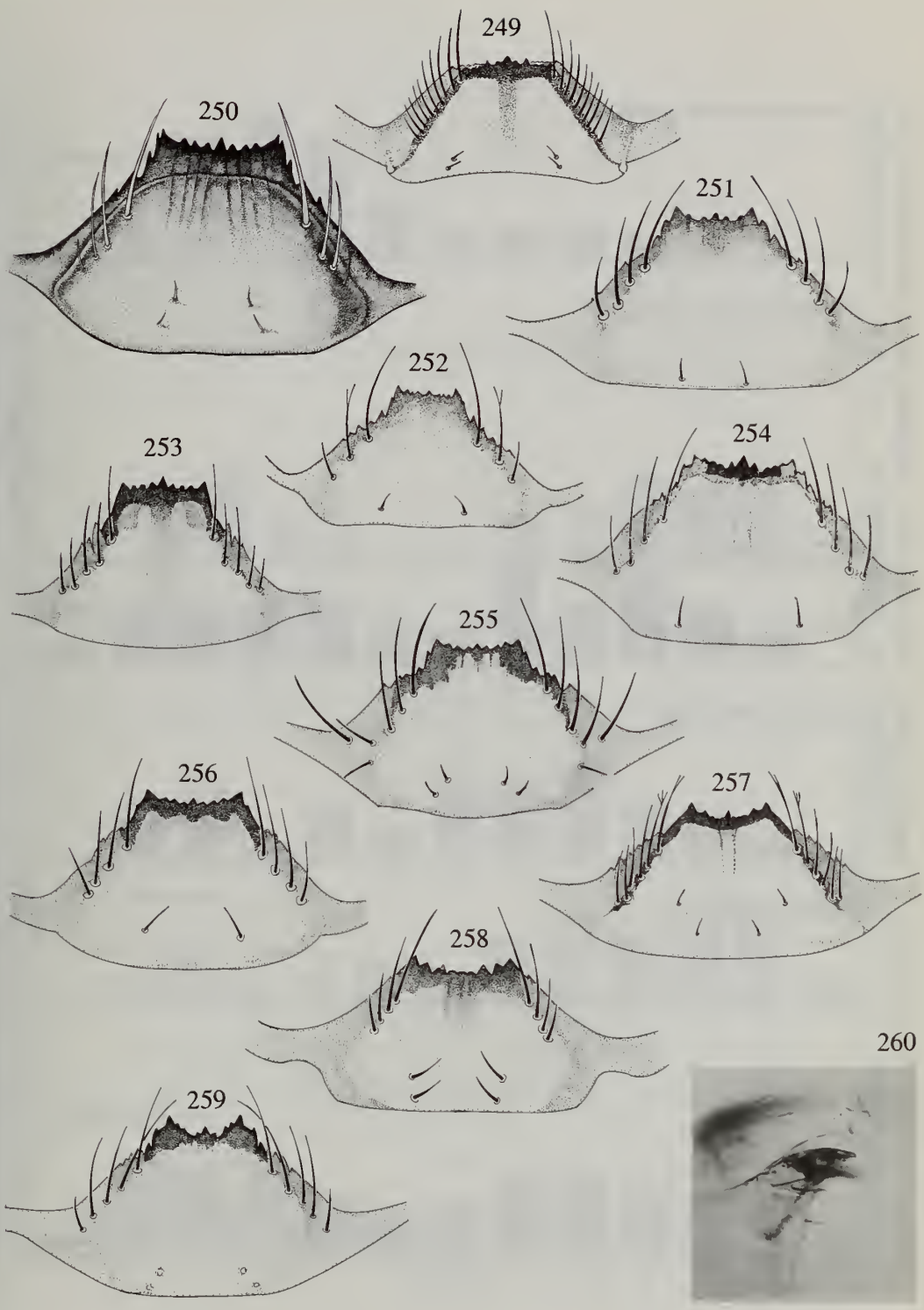


Figs 224–237 Larval head patterns of: 224, *S. rubrithorax*; 225, *S. exiguum* (positive pattern); 226, *S. exiguum* (negative pattern); 227, *S. quadrifidum*; 228, *S. oyapockense* ; 229, *S. incrustatum* (positive pattern); 230, *S. bipunctatum* (positive pattern); 231, *S. bipunctatum* (negative pattern); 232, *S. iracouboense*; 233, *S. lutzianum*; 234, *S. rorotaense* (positive pattern); 235, *S. rorotaense* (negative pattern); 236, *S. guianense*; 237, *S. goeldii.*





Figs 238–248 Ventral view of head showing postgenal cleft and bridge of: 238, *S. rubrithorax*; 239, *S. exiguum*; 240, *S. quadrifidum*; 241, *S. oyapockense*; 242, *S. incrustatum*; 243, *S. bipunctatum*; 244, *S. iracouboense*; 245, *S. lutzianum*; 246,*S. rorotaense*; 247, *S. guianense*; 248, *S. goeldii*.



Figs 249–260 Hypostomium of: 249, *S. rubrithorax*; 250, *S. exiguum*; 251, *S. quadrifidum*; 252, *S. oyapockense*; 253, *S. incrustatum*; 254, *S. bipunctatum*; 255, *S. iracouboense*; 256, *S. lutzianum*; 257, *S. rorotaense*; 258, *S. guianense*; 259, *S. goeldii*. Mandible of: 260, *S. goeldii*.

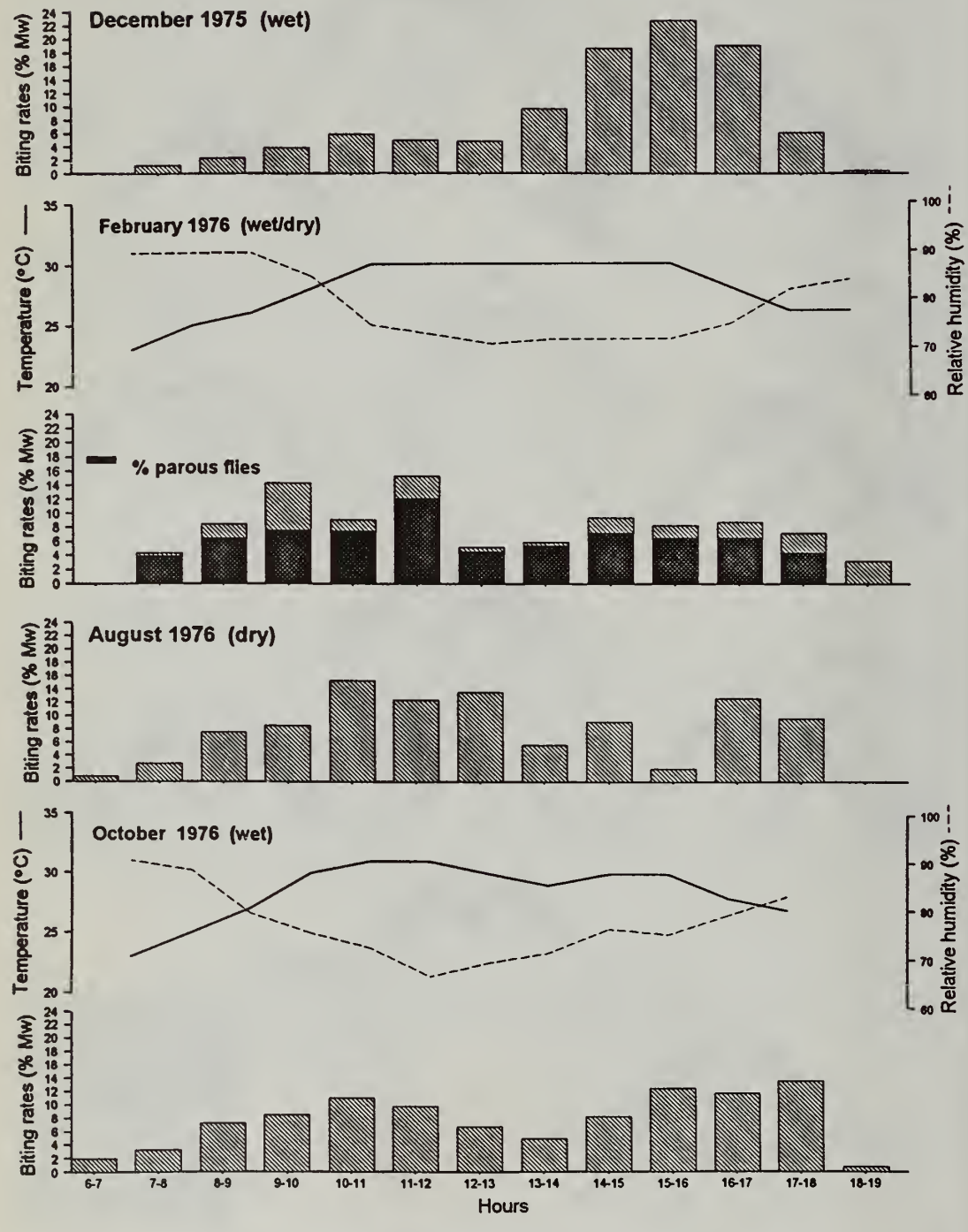


Fig. 261 Seasonal biting cycles and parous rates of *S. oyapockense/roraimense* at Tootobi (December 1975–October 1996).

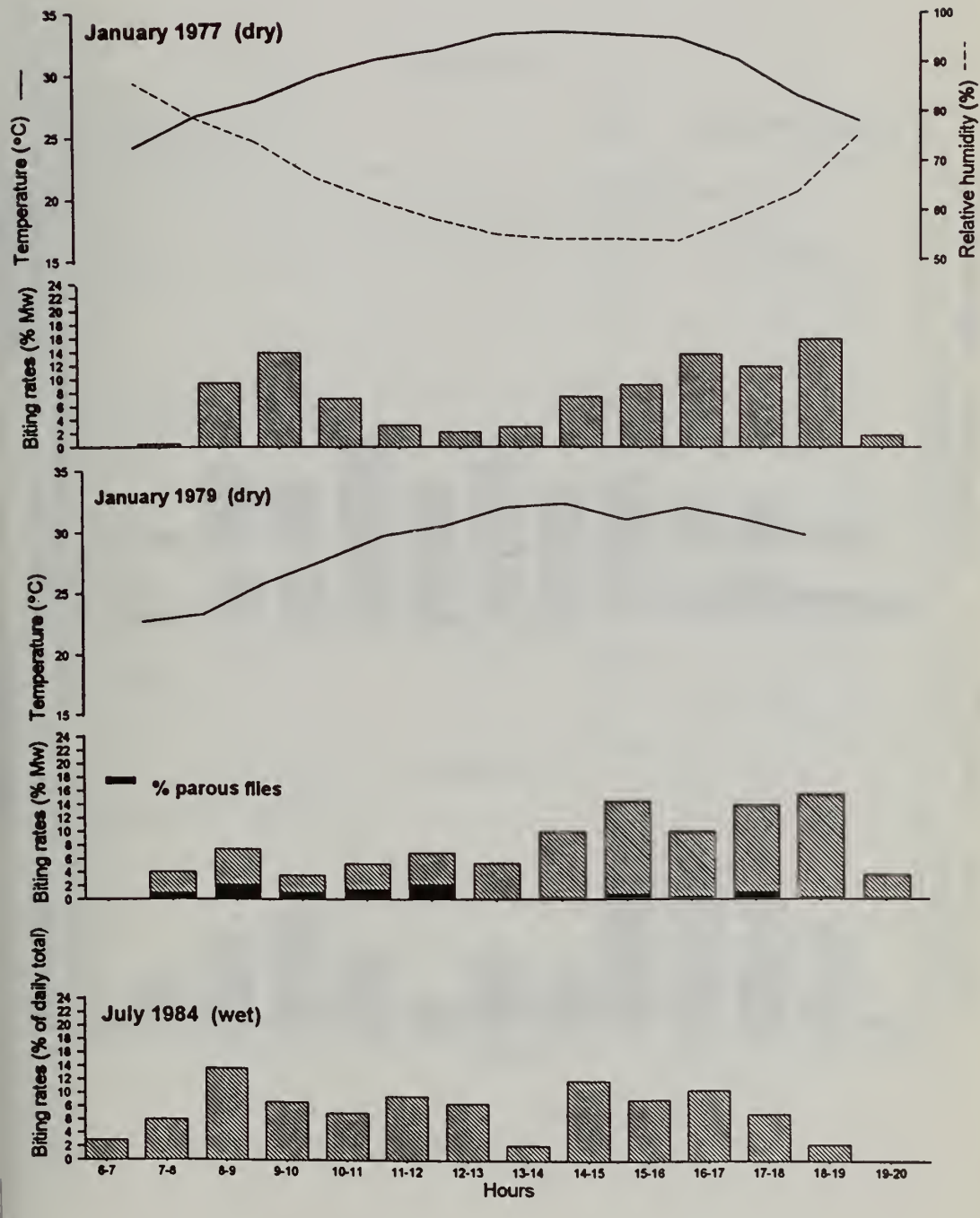


Fig. 262 Seasonal biting cycles and parous rates of *S. oyapockense/roraimense* at Tootobi (January 1977–July 1984).

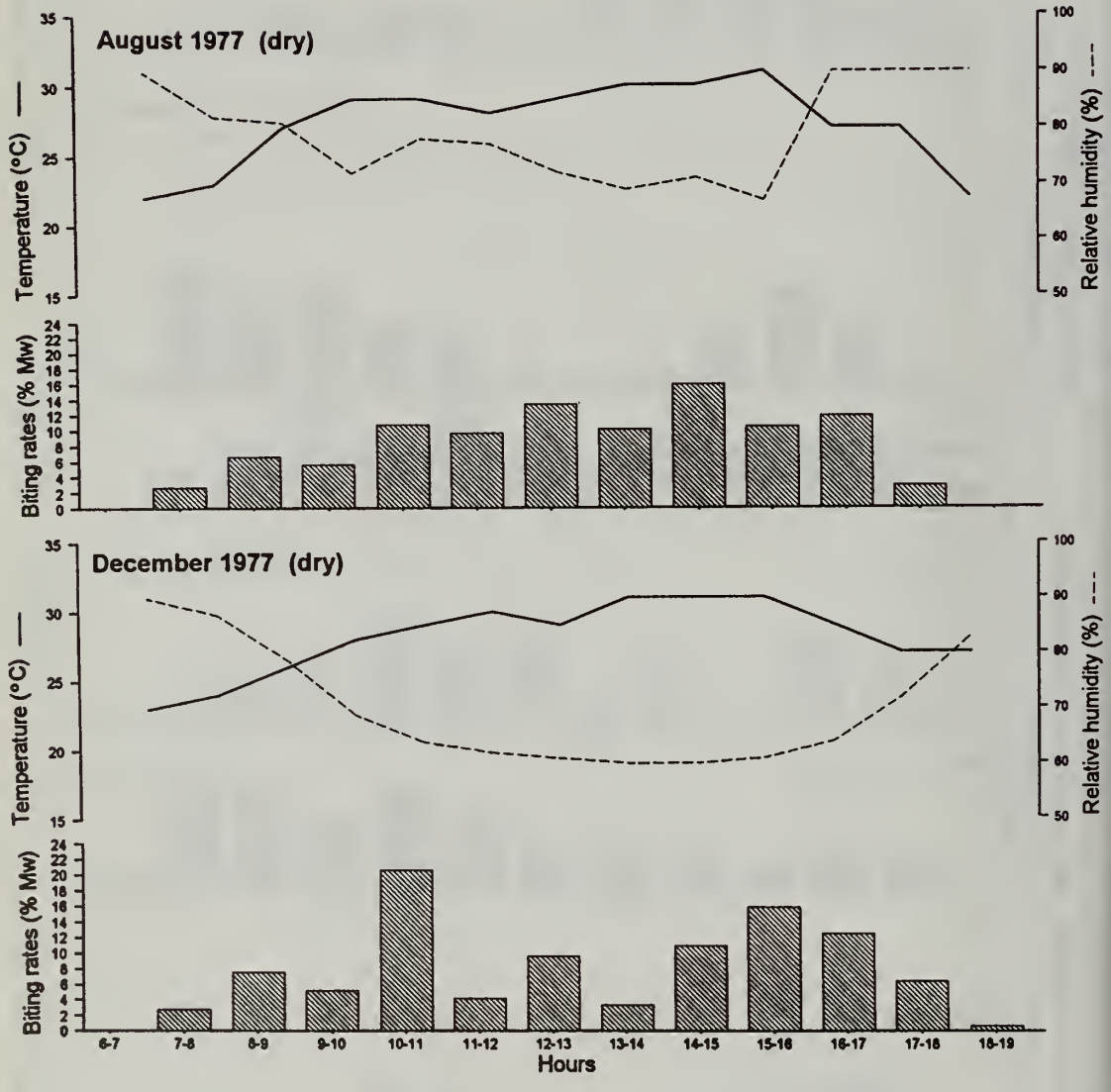


Fig. 263 Seasonal biting cycles of *S. oyapockense/roraimense* at Catrimani.

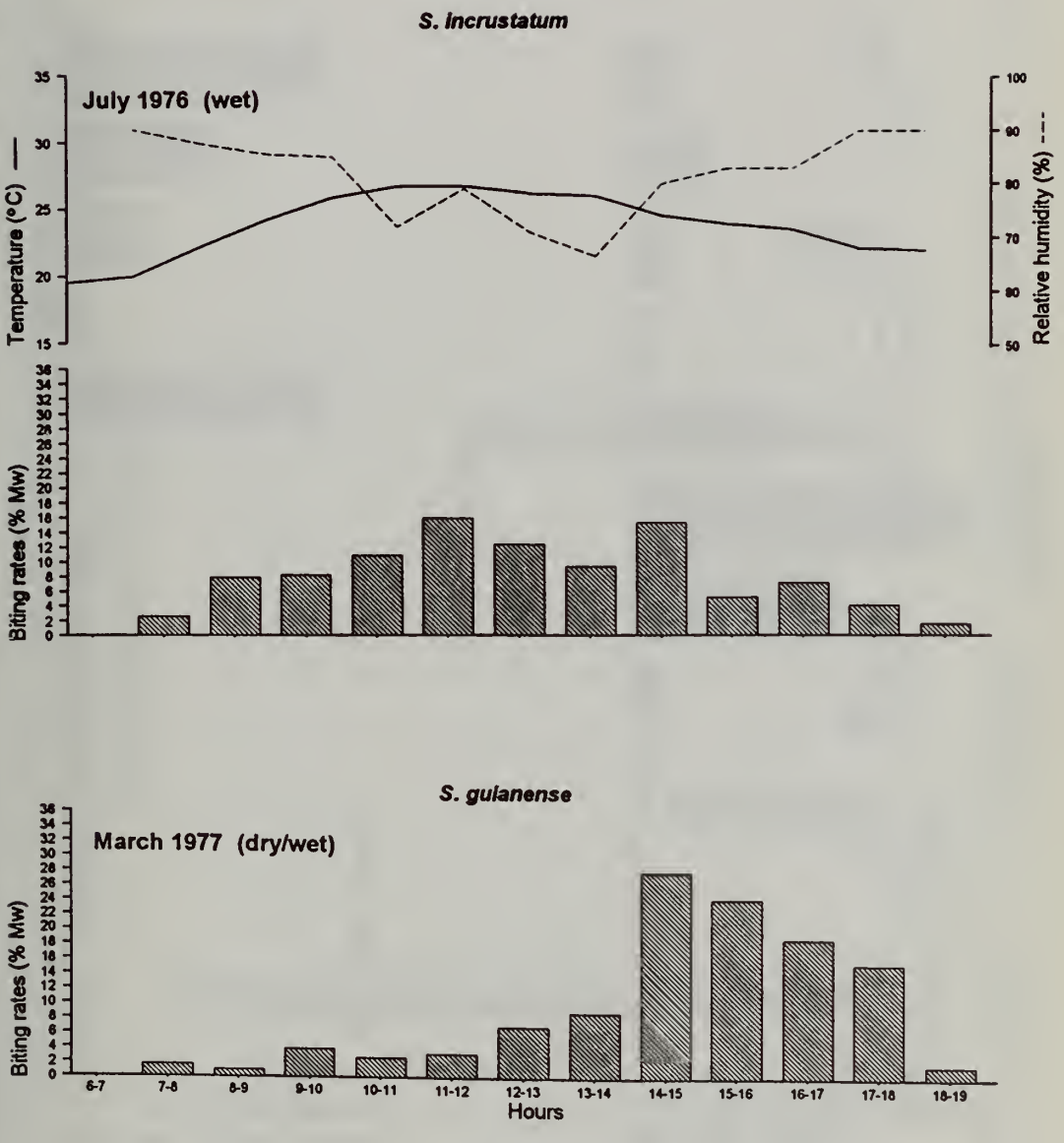


Fig. 264 Biting cycles of *S. incrustatum* and *S. guianense* at Auaris.

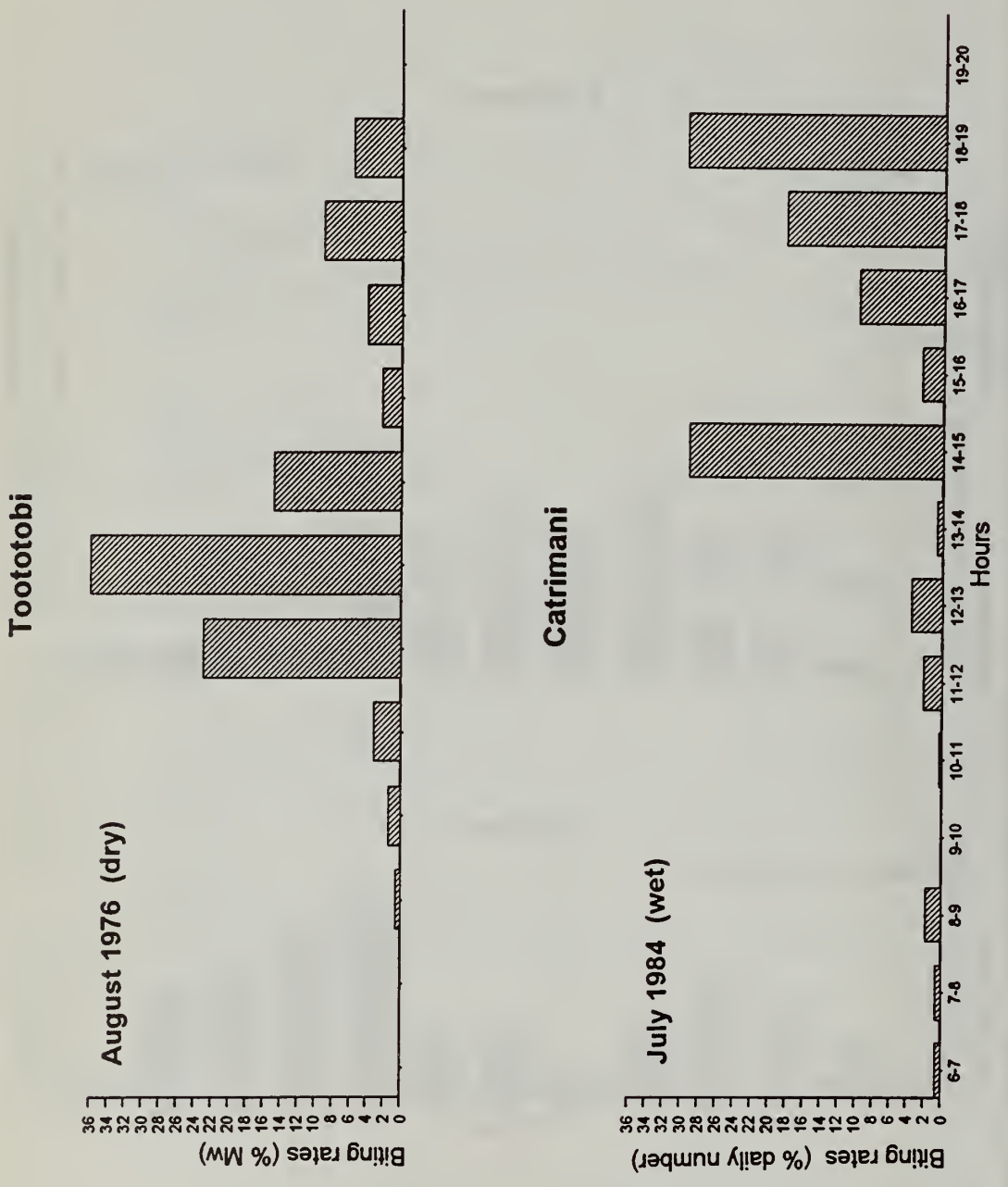


Fig. 265 Biting cycles of *S. exiguum* at Toototobi and Catrimani.

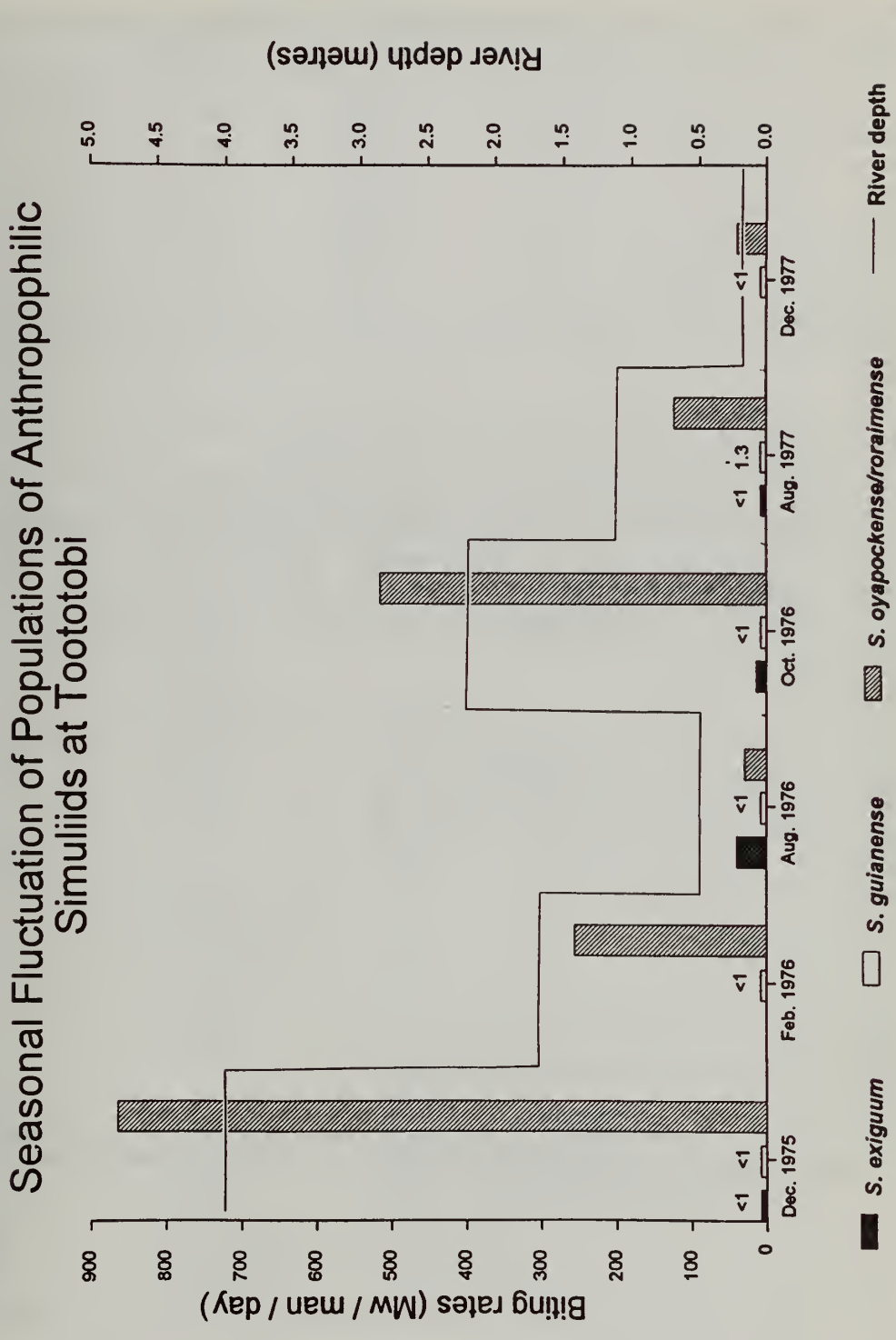


Fig. 266 Seasonal fluctuation of anthropophilic simuliids in relation to river depth at Toototobi.

Table 1 Distribution of simuliid species in the Amazonia onchocerciasis focus of Brazil

Simuliid species	Lowland				Highland	
	Toototobi	Catrimani	Mucajai	Parimiu*	Auaris	Surucucus
bipunctatum	–	–	–		m	–
cauchense	–	–	i		i	i
exiguum	m	im	im		m	–
goeldii	–	–	–		–	i
guianense	m	i	i		m	m
incrustatum	–	–	m		im	m
iracouboense	–	i	i		–	–
lutzianum	–	–	–		i	–
oyapockense/roraimense	im	im	m	m	m	–
quadrifidum	i	–	i		i	i
rorotaense	–	–	i		im	i
rubrithorax	–	–	–		–	i
suarezi	–	–	–		–	i

* Parimiu – no collection of immature stages; i – immature stages; m – man biting females.

Table 2 Distribution of simuliid species in the Amazonia onchocerciasis focus – Venezuela

	Lowland					Foothills	Highland				
Simuliid species	Boca de Mavaca	Platanal	Caño Babilla	Raudal-Guajaribo	Peñascal	Coyowa-teri	Parima A	Parima B	Alto Ventuari	Upper Caura	R. Siapa
amazonicum	–	–	–	–	–	–	–	–	–	m	–
beaupertuyi	–	–	–	–	–	–	–	i	–	–	–
clarki	–	–	–	–	–	–	–	–	m	–	–
bipunctatum	–	–	–	–	–	–	m	m	–	–	–
cauchense	–	–	–	–	–	–	–	i	–	–	–
covargarciai	–	–	–	–	–	–	–	i	–	–	–
exiguum	–	–	–	–	i	im	–	–	–	m	–
guianense	–	–	m	m	im	m	m	m	–	m	–
incrustatum	–	–	–	–	–	m	i	im	–	m	–
iracouboense	–	–	–	–	i	–	–	–	–	–	–
limbatum	+	+	–	–	–	–	–	–	+	–	–
lutzianum	–	–	–	–	–	–	i	i	–	–	–
matteabranchia	–	–	–	–	–	–	i	–	–	–	–
morae	–	–	–	–	–	–	–	i	–	–	–
nuneztovari	–	–	–	–	–	–	–	–	i	–	–
oyapockense/ roraimense	m	m	m	m	m	m	–	m	–	m	m
parimaense	–	–	–	–	–	–	–	i	–	–	–
perflavum	–	–	–	–	–	–	i	–	–	–	–
quadrifidum	–	–	–	–	–	–	–	i	–	–	–
rorotaense	–	–	–	–	i	–	–	i	–	–	–
suarezi	–	–	–	–	–	–	i	i	–	–	–

Data sources - Rassi *et al.*, 1983; Basañez *et al.*, 1988; Ramírez Pérez, 1983; Ramírez Pérez *et al.*, 1977, 1982, 1986; Suarez *et al.*, 1992. i – immature stages; m – man-biting females; + – stage not recorded.

Table 3 Daily man-biting rates (Mw) of major anthropophilic species in Brazil

Locality	Date	Season	*S. oyapockense/roraimense*	*S. guianense*	*S. incrustatum*	*S. exiguum*
Tootobi	Dec.75	wet	866.4	<1.0	0	<1.0
	Feb.76	wet/dry	256.7	<1.0	0	0
	Aug.76	dry	29.0	<1.0	0	40.5
	Oct.76	wet	515.1	<1.0	0	14.0
	Aug.77	dry	124.5	1.3	0	<1.0
	Dec.77	dry	38.5	<1.0	0	0
Catrimani	Jan.77	dry	2479*	0	0	0
	Jan.79	dry	696.4	0	0	0
	Jul.84	wet	6780*	0	0	273*
Auaris	Jul.76	wet	0	<1.0	138.2	<1.0
	Mar.77	dry/wet	3.6	116.6	9.2	<1.0

* Actual number biting in a one day catch

Table 4 List of names of important anthropophilic simuliid species in papers dealing with biology and medical importance

Current name	Cited as	Reference
exiguum	*Simulium* sp.C	Shelley *et al.*, 1976
guianense	*pintoi*	Ramirez Pérez, 1983, 1984, 1985, 1986; Ramírez Pérez *et al.*, 1982; Rassi & Monzon, 1981; Rassi *et al.*, 1977; Tada, 1983; Takaoka *et al.*, 1984
	pintoi or *guianense*	Lacey, 1981; Moraes *et al.*, 1978, 1979
	pintoi (guyanensis)	Godoy *et al.*, 1989
	pintoi & orbitale	Rassi, 1974
	Simulium sp.B	Shelley *et al.*, 1976
incrustatum	*limbatum*	Basáñez *et al.*, 1988?; Moraes, 1991
	opalinifrons	Coscaron & Wygodzinsky, 1973
	yarzabali	Moraes, 1991; Ramírez Pérez, 1980; Shelley, 1988; Shelley *et al.*, 1987a; Tada, 1983
oyapockense/ roraimense	*amazonicum*	Ramírez Pérez, 1983; Rassi & Monzon, 1981;Rassi *et al.*,1975a,b; 1977, 1978
	amazonicum complex (amazonicum & minusculum)	Rassi, 1974
	amazonicum group	Tada, 1983
	amazonicum or *sanguineum*	Moraes *et al.*, 1979
	amazonicum & *sanguineum*	Godoy *et al.*, 1986
	cuasisanguineum	Ramírez Pérez, 1983, 1984, 1985, 1986; Ramírez Pérez *et al.* 1982; Suárez *et al.*, 1992; Tada, 1983; Takaoka *et al.*, 1984; World Health Organization 1982
	minusculum	Nathan *et al.*, 1982; Shelley *et al.*, 1982
	pseudosanguineum	Ramírez Pérez & Peterson, 1981a
	sanchezi	Botto *et al.*, 1983; Ramírez Pérez *et al.*, 1982; Yarzábal *et al.*, 1983
	sanguineum	Moraes *et al.*, 1978; Shelley *et al.*, 1979a,b, 1980
	sanguineum s.l.	Lacey, 1981; Lacey Charlwood, 1980
	sanguineum group	Tidwell *et al.*, 1980
	sanguineum group, forms A, B and C	Tidwell *et al.*, 1981a
	Simulium sp. A	Shelley *et al.*, 1976

Table 5 Natural infection rates of simuliids with *Onchocerca* species in Brazil

Locality (altitude)	Date	Season	*S. oyapockense/roraimense*				*S. guianense*			
			Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found	Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found
Toototobi	Dec.1975	Wet	278	0.4	0	L1	0	–	–	–
(180m)	Feb.1976	Dry	417	0.5	0	L1	0	–	–	–
	Aug.1976	Dry	0	–	–	–	0	–	–	–
	Oct.1976	Wet	265	0.7	0	mff	2	0	0	–
	Dec.1976	Wet	71	1.4	0	mff	0	–	–	–
	Aug.1977	Dry	453	–	0	–	0	–	–	–
	Dec.1977	Dry	312	0.9	0.3	L1,L3	0	–	–	–
	TOTAL		1796	0.5			2	0	0	–
Catrimani	Jan.1977	Dry	2479	0.2	0	L1,L2	0	–	–	–
(230m)	Jan.1979	Dry	616	0.5	0.2	L1,L3	0	–	–	–
	TOTAL		3095	0.2	<0.1		0			
Auaris	Jul.1976	Wet	0	–	–	–	0	–	–	–
(670m)	Mar.1977	Dry/Wet	5	0	0	–	165	3.0	0.6	L1,L2,L3
	TOTAL		5	0	0		165	3.0	0.6	

Table 5 cont.

S. incrustatum				*S. exiguum*			
Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found	Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found
0	–	–	–	0	–	–	–
0	–	–	–	0	–	–	–
0	–	–	–	202	1.5	0	L1
0	–	–	–	17	23.5	0	L1,L3*
0	–	–	–	0	–	–	–
0	–	–	–	0	–	–	–
0	–	–	–	0	–	–	–
0	–	–	–	219	3.2	0	
0	–	–	–	0	–	–	–
0	–	–	–	0	–	–	–
0				0			
328	1.3	0.3	L1,L3	0	–	–	–
14	0	0	–	3	33.3	0	L1
342	0.9	0.3		3	33.3	0	

mff=microfilaria; L1 =sausage stage; L2 =preinfective stage; L3 =infective *O. volvulus*; * =not *O. volvulus*.

Table 6 Natural infection rates of simuliids with Onchocerca species in Venezuela

Locality (altitude)	Season	S. oyapockense/roraimense				S. guianense				S. incrustatum			
		Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found	Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found	Total dissected	Infection rate (%)	Infectivity rate (%)	Stages found
Parima B[2,3]	wet/dry	0	–	–	–	447	4.7	0.2	L1,L3	0	–	–	–
(950m)	wet/dry	2	0	0	–	642	4.0	0.2	L1,L3	33	0	0	–
Coyowe Teri[1,3]	dry	0	–	–	–	100	8.0	2.0	L1,L3,	0	–	–	–
(250m)	wet/dry	24	0	0	–	1290	10.2	1.3	L1,L3,	66	1.5	1.5	L3
Upper[1,3]	dry	400	0.2	0.2	L3	0	–	–	–	0	–	–	–
Orinoco (150m)	wet/dry	989	0.5	0.1	–	19	5.3	0	L1	0	–	–	–

[1]data from Rassi *et al.*, 1977; [2]data from Tada 1983; [3]data from Basáñez *et al.*, 1988.

APPENDIX 1

Material examined

Specimens examined are preserved dried on pins (with associated pupal exuviae if reared, in a polyurethane tube in glycerol), dried in glass tubes after having the cuticular hydrocarbons examined, mounted on slides or in 80% alcohol.

Simulium (Hemicnetha) rubrithorax Lutz

PINNED

Brazil: 1♀ (reared), **Roraima State**, Boa Vista-Santa Helena road, Boca da Mata, Igarapé Cunaen, feeder stream, 11.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), **Goias State**, Córrego Sonhem, DF. 2A, near R. Palmeiras, 5.iv.1976 (*A.J. Shelley*), (BMNH); 1♀ (reared), Córrego Bandeirinha, 1st permanent stream on Formosa-Itiquira road, 26.ix.1975 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), **Minas Gerais State**, Mantiqueira Mts., stream at Pedralva, Fazenda Sto. Antonio, 19–22.v.1979, B.M.1979–258, (*R.W. Crosskey & A.J. Shelley*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), **São Paulo State**, northern Serra da Bocaina, Fazenda Barra de Turvo, 3km east of Bananal, (Locality 16), 15–18.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), northern Serra da Bocaina, Km 264, SP.66, 15–18.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 1♀, **State not recorded**, Cantagallo, viii.1904 (*Fajardo*), (BMNH).

SLIDE MOUNTED

Brazil: 2 larvae, **Roraima State**, Surucucus, waterfall, 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (dissected from pupa), 1♂ (dissected from pupa), 2 pupae, 2 larvae, **Minas Gerais State**, Mantiqueira Mts., Pedralva, stream on Pedralva-São Lourenço road, (Locality 29), 19–22.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 1 larva, Pedralva, Fazenda Sto. Antonio, waterfall, 15.vi.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3 pupae, 2 larvae, **São Paulo State**, northern Serra da Bocaina, Fazenda Barra de Turvo, 3km east of Bananal, (Locality 16), 15–18.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH).

SPIRIT MATERIAL

Brazil: 6 larvae, **Roraima State**, Surucucus, waterfall, 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous pupae, 3 larvae, **Goias State**, Córrego Bandeirinha, Formosa-Itiquira road, 26.ix.1975, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), Belem-Brasilia Highway, BR 153, Km 146 from Anapolis, small stream, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); numerous pupae and larvae, **Minas Gerais State**, Mantiqueira Mts., Pedralva, stream on Pedralva-São Lourenço road, (Locality 29), 19–22.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); numerous pupae and larvae, Pedralva, Fazenda Sto. Antonio, waterfall, 15.vi.1979, (*A.J. Shelley*) & (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), numerous pupae, numerous larvae, **São Paulo State**, northern Serra da Bocaina, Fazenda Barra de Turvo, 3km east of Bananal, (Locality 16), 15–18.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); numerous pupae, northern Serra da Bocaina, Km 264, SP.66, west of S. José do Barreiro (Locality 21), 15–18.v.1979 (*R.W. Crosskey & A.J. Shelley*), (BMNH).

Simulium (Notolepria) exiguum Roubaud

TYPE MATERIAL

Venezuela: 1♀ LECTOTYPE & 5♀♀ PARALECTOTYPES (pinned), Sarare, 1899 (*F. Geay*), (MNHN, BMNH).

as *Simulium glaucophthalmum* Knab

Peru: 1♀ HOLOTYPE, Santa Clara, 1914 (*C.H.T. Townsend*) (USNM).

as *Simulium urubambanum* Enderlein

Peru: 1♀ HOLOTYPE, Rosalina, R. Urubamba, 28.viii.1903 (*collector not stated*), (ZMHU).

PINNED

Brazil: 2♀♀ (reared), 2♂♂ (reared), **Roraima State**, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*, (BMNH); 1 man-biting ♀, 14♀♀ (reared), 7♂♂ (reared), Catrimani mission, R. Catrimani, 9.i.1977 & 12, 13 & 16.i.1979, B.M.1979–580 (*A.J. Shelley*) & (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 9♀♀ (reared), 5♂♂ (reared), R. Mucajaí, near mission post, 200m below Igarapé Coroconaí, 21.vii.1984, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Mucajaí mission post, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), northern perimeter road, R. Agua Preta, 18.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Normandia, Igarapé Inamarú, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (caught at black light), Posto Meva, R. Auaris, 4°8'N, 64°29'W, 3.iv.1977 (*R.R. Pinger*), (BMNH); 13♀♀ (reared, 1 pupal exuviae missing), 16♂♂ (reared, 1 pupal exuviae missing), R. Preto, tributary of R. Ajaraní, 28–29.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, 2♀♀ (reared), 7♂♂ (reared), Vila Pereira, R. Surumu, 25 & 26.xi.1980, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Cachoeira, R. Cauamé, 2.xii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 11 man-biting ♀♀, **Amazonas State**, mission post, R. Toototobi, 16.viii.1976, 25.x.1976, B.M.1979–580 (*R.R. Pinger*) & 24.x.1976, 24.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1 man-biting ♀, 5♀♀ (5 reared; 1 pupal exuviae missing), 3♂♂ (2 reared), **Mato Grosso State**, R. Aripuanã, 29.vi.1978, B.M.1979–580 (*J.D. Charlwood*), 30.v.1978 & 12.ix.1978 (*L.A. Lacey*), (BMNH).

Argentina: 3♀♀ (originally identified as *S. delpontei*), Jujuy, xii.1938, B.M.1949–76 (*W.C. Paterson*), (BMNH); 1♀, Salta, Dique Fligoro, San Martin, 14.v.1970 (*Satelo*), (BMNH).

Bolivia: 2♀♀, Covendo, 1921–22 (*W.M. Mann*), (BMNH);

1 tapir-biting ♀, HuachiBeni, August, 1921–1922 (*W.M. Mann*), (BMNH); 2♀♀ (originally identified as *S. delpontei*), Villa Montes, v.1926, B.M.1933–168, (*Lind. D. Chaco Exp.*), (BMNH).

Colombia: 3♀♀, **Sierra Nevada de Santa Marta**, Ariguani, 22.xii.1963 (*J.P. Lee-Potter*), (BMNH); 2♀♀, Valledupar area, 15.i.1964 (*J.P. Lee-Potter*), (BMNH); 1♀, Meollaca, 22.xii.1963 (*J.P. Lee-Potter*), (BMNH); 2 man-biting ♀♀, **Dept. Valle**, Tunselas, approx. 7km west of Dagua, 16.iii.1977 (*J. Ardila*), (BMNH).

Ecuador: 23 man-biting ♀♀, **Esmeraldas Province**, San Miguel de Cayapa, R. Cayapa, 18–21 & 25.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀, R. Cayapa, 0°42'N 78°54'W, 28.vi.1980 (*M.E. Arzube*), (BMNH); 2♀♀ (reared), 4♀♀ (reared), Tumbaviro, R. Sapallo Grande, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 86 man-biting ♀♀, 7♀♀ (reared), 6♂♂ (reared), Naranjal, R. Canandé, 25.ix.1983, 21 & 24.vi.1985, 3.vi.1988 (*A.J. Shelley & M.Arzube*), (BMNH); 20♀♀ (reared), 18♂♂ (reared; 1 pupal exuviae missing), Naranjal (on R. Canandé), R. Naranjal, 23.vi.1985 & 3.vi.1988 (*A.J. Shelley & M.Arzube*), (BMNH); 18 man-biting ♀♀, 5♀♀ (reared), 7♂♂ (reared), Naranjal (on R. Canandé), R. Aguas Negras, 25.ix.1983 & 3.vi.1988 (*A.J. Shelley & M.Arzube*), (BMNH); 2 man-biting ♀♀, Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Salazar, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, 1♂ (reared), Santo Domingo-Esmeraldas road, road to Puerto Quito, near Concordia, R. Caoni, 24.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 5˘˘ (reared), 3♂♂ (reared), Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Blanco, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 60m, R. Sapotal, 26.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, **Bolivar Province**, Babahoyo-Balzapamba-Aguaranda road, in direction of Balzapamba, R. Chanpiaco, 10.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 6 man-biting ♀♀, 5♀♀ (reared), 3♂♂ (reared), **Cotopaxi Province**, Quevedo-La Maná-Pilaló road, near La Maná (after), 240m, R. San Pablo, 8.vi.1984 (*A.J. Shelley & M.Arzube*), (BMNH); 1♂ (reared), Quevedo-La Maná-Pilaló road, after La Maná, 260m, Recinto Beles, R. San Pablo bridge, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 4 man-biting ♀♀, **El Oro Province**, Machala-Uzcrume road, after Pasaje, 80m, R. Guesha, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, Machala-Uzcrume road, 220m, river name unknown, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Machala-Uzcrume road, after Pasaje, 80m, R. Jubones, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, 4♀♀ (reared), 2♂♂ (reared), Machala-Piñas road, before Zaruma, after Santa Rosa, 50m, R. Carne Amarga, 21.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 6 man-biting ♀♀, 1♀ (reared), Machala-Naranjal road, canal de Riego, R. Bucay, 12.xii.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 38 man-biting ♀♀, 3♀♀ (reared), 2♂♂ (reared), **Guayas Province**, Naranjal-Machala road, via Cooperativa 11 de Agosto, 80m, R. Bucay, 19.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), Naranjal-Machala road, via Cooperativa 11 de Agosto, 50m from R. Bucay, forest stream, 19.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀♀, **Imbabura Province**, Salinas road, 20km north of Ibarra, bridge over R. Tahuando, 8.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, 4♀♀ (reared), 4♂♂ (reared), Salinas-Lita road, 45km from Ibarra, San Juan del Hacha, R. Mira, 11.ix.1983 (*A.J. Shelley & M. Arzube*, (BMNH); 3♀♀ (reared), 3♂♂ (reared), Salinas-Lita road, 40km from Ibarra, un-named stream, 11.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Salinas-Lita road, 54km from Ibarra, R. San Pedro, 11.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 14 man-biting ♀♀, 2♀♀ (reared), **Loja Province**, Loja-La Toma road, 1360m, Hacienda Monteray, R. Guayabal, 23.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, **Los Ríos Province**, Babahoyo-Montalvo road, R. Cristal, 10.vi.1984 (*A.J. Shelley & M.Arzube*), (BMNH); 6 man-biting ♀♀, 1♂ (reared), **Manabi Province**, Santo Domingo-El Carmen road, Km 40, 2km past El Carmen, R. Suma, 7.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 13 man-biting ♀♀, 15♀♀ (reared), 12♂♂ (reared), **Napo Province**, near Lago Agrio, R. San Miguel, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀♀, near Lago Agrio, Posto 19, R. Tarapa, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, near Lago Agrio, road from Lago Agrio to Colombia, R. Teteye, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), near Lago Agrio, border with Colombia, 20km from Texaco base, R. San Miguel, 9.xii.1982 (*A.J. Shelley & M.Arzube*), (BMNH); 15 man-biting ♀♀, 8♀♀ (reared), 6♂♂ (reared), near Lago Agrio, R. Aguarico, Dureno, 12 & 13.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 8 man-biting ♀♀, Tena, 1km from Misahualli, 400m, alongside R. Napo, 7.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, **Pastaza Province**, Puyo-Shell Mera road, 1km after Shell Mera, confluence of R. Alpayacu and R. Pastaza, 10.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, Tena-Puyo road, via Puerto Napo, 460m, R. Mira Valle, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH).

Venezuela: 1 pupal exuviae, **Guarico State**, San Francisco de Macaira, Dro Monagas, 450m, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 2♀♀, **Miranda State**, 300m, 1949, B.M.1950–137 (*D.R. Triarte*), (BMNH); 1♀, 7–800m, 1949, B.M.1950–137 (*D.R. Triarte*), (BMNH); 1♀ (reared), Tacata, no date, (*J. Ramírez*), (BMNH); numerous man-biting ♀♀, **Monagas State**, Caripe area, iv.1961 (*D.J. Lewis*), (BMNH); 4♀♀, 1♂, Caripe area, R. Guarapiche, 6.iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀, Caripe area, La Pumerosa, v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀, Caripe area, R. Santa Maria, 7.iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 9 man-biting ♀♀, San Antonio de Maturin, (near Caripe), 7.iv.1961 (*D.J. Lewis*), (BMNH); 1 man-biting ♀, Caripe area, El Maro, 8.iv.1961 (*D.J. Lewis*), (BMNH); 2 man-biting ♀♀, El Quebracho, (near Caripe), 8.iv.1961 (*D.J. Lewis*), (BMNH); 1♀ (reared), 2♂♂ (reared), 1 pupal exuviae, **Trujillo State**, Carache, 1250m, no date, B.M.1969–676 (*collector not stated*), (BMNH); 3♀♀ (reared), 5♂♂ (reared), **Yaracuy State**, R. Yaracuy, no date, B.M.1969–676 (*J. Ramírez*), (BMNH).

SLIDE MATERIAL

Brazil: 1♀ (reared), 1♂ (reared), **Roraima State**, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*, (BMNH); 7 man-biting ♀♀, 2♀♀ (reared), 7♂♂ (reared; 1 pupal exuviae missing), 14 larvae, Catrimani mission, R. Catrimani, 12.i.1979, B.M.1979–580 & 14.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), R. Mucajaí, near mission post, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 3♂♂ (reared), R. Mucajaí, 200m below Igarapé

Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1 larva, R. Mucajaí, near mission post, Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 larva, R. Mucajaí, 20.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 1♂, northern perimeter road, R. Agua Preta, 29.iv.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*) & 18.xi.1980 (*A.J. Shelley*), (BMNH); 1♂ (reared), R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 1♂ (reared), Vila Pereira, R. Surumu, 25 & 27.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Cachoeira do R. Cauamé, 22.xi.1980 (*A.J. Shelley*), (BMNH); 1 man-biting ♀♀, **Amazonas State**, mission post, R. Tootototobi, 26.ii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1 man-biting ♀, R. Ituxi, v.1978, B.M.1979–580 (*D. Roberts*), (BMNH); 1♀ (reared), 1♂ (reared), **Mato Grosso State**, R. Aripuanã, 29.vi.1978, B.M.1979–580 (*J.D. Charlwood*), (BMNH); 1♀ (reared), 1♂ (reared), **Federal District**, Brasilia, under bridge on highway DF 6, R. São Bartolomeu, 12.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 1♀ (reared), R. Palmeiras (Maranhão), 5.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 1♀ (reared), 1♂ (reared), **Goias State**, Formosa-Itiquira road, Córrego Bandeirinha, 23.iii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH).

Colombia: 2 man-biting♀♀, **Department Valle**, Tunselas, approximately 7km west of Dagua, 16.iii.1977 (*J. Ardila*), (BMNH).

Ecuador: 18 man-biting♀♀, 11 horse biting♀♀, 1♂ (reared), 33 larvae [31 cytotyped as Cayapa Form], **Esmeraldas Province**, Naranjal, R. Naranjal, (Canandé), 25.ix.1983, 22 & 23.vi.1985 & 3.vi.1988 (*A.J. Shelley & M. Arzube*) & 29.v.1993 (*M. Charalambous, B. Smithies & M. Arzube*), (BMNH); 6 man-biting ♀♀, 2♂♂ (reared), 1 pupal exuviae, 8 larvae, Naranjal, R. Canandé, 25.ix.1983 & 21 & 24.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, Naranjal (R. Canandé), nuns' house, 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, Naranjal (on R. Canandé), Calle Mansa, riachuelo, 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, 2♂♂ (reared), 1 larva, Tumbaviro, R. Sapallo Grande, 24 & 26.v.1981 & 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), R. Grande (Cayapa), Viruela, 24.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 pupal exuviae, Calle Mansa, R. Cayapa, 27.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Salazar, 28.ix.1983 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 larva, Santo Domingo-Esmeraldas road, near Concordia, road to Puerto Quito, R. Caoni, 24.ix.1983 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 19 larvae, [cytotyped as Quevedo Form], **Cotopaxi Province**, La Maná, R. Pilaló, 24.ix.1991 (*M. Charalambous & M. Arzube*, (BMNH); 2 man-biting ♀♀, **Napo Province**, near Lago Agrio, R. Aguarico, 4km from Texaco base, 10.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH).

Guatemala: 3♀♀, 3♂♂, 3 pupal exuviae, 8 larvae, R. Nahualate, Finca Pastores, Antigua, 16.vi.1948 (*H.T. Dalmat & A. Castellanos*) & 8.vi.1951 (*J. Rosales & A. Castellanos*), (BMNH); 1♀ (reared), 1♂, R. Nahualate, Finca Monte Santo, Chicacao, Suchitepequez, 14.i.1948 (*M. Rodriguez*), (BMNH); 1♀, 1♂, R. Nahualate, Nahualate, Chicacao, Suchitepequez, 4.x.1947 (*M. Rodriguez*), (BMNH); 3♀♀, 2♂♂, R. Esquipulas, Esquipuias-Chiquimula, 14.i.1948 (*O. Ochoa A, H. Ochoa A. & H.T. Dalmat*), (BMNH); 1 pupa, R. Puenta Esquipulas, Esquipulas, Chiquimula, 14.i.1948 (*O. Ochoa A, H. Ochoa A. & H.T. Dalmat*), (BMNH); 1♀, R. La Torre, Finca La Torre, Acatenango, Chimaltenango, 25.vii.1949 (*E. Castillo*), (BMNH); 1 pupal exuviae, R. Chinamita, Finca Bobos, Morales, Izabali, 1.ii.1950 (*O. Ochoa A. & H.T. Dalmat*), (BMNH).

Panama: 1♀ (reared), **Darien Province**; Morti, 10.i.1985 (*J. Petersen*), (BMNH).

Venezuela: 4 man-biting ♀♀, **Monagas State**, Caripe Area, El Rincón, 7.v.1961, (*D.J. Lewis*),(BMNH); 1♂, Caripa area, 16.v.1961 (*D.J. Lewis*), (BMNH); 1♀ (reared), 2♂♂ (1 reared), 3 pupal exuviae, La Pumerosa, 420m, Purto el Poto, iv.1961 (*D.J. Lewis*), (BMNH); 2 man or donkey biting ♀♀, El Quebracho (near Caripe), 7.v.1961 (*D.J. Lewis*), (BMNH); 1♂, R. Guarapiche, 6.iv.1961, (*D.J. Lewis*), (BMNH); 1♂, R. Guarapichc, Punto el Carro, 400m, 9.v.1961 (*D.J. Lewis*), (BMNH); 1♀ (part only) **State not recorded**, [No. 6268], xii.1945 (*D. Iriarte*), (BMNH); 1♀ (part only) [No. 6271], Reg. de los Andes, 10.ix.1949 (*B. Iragorry*), (BMNH).

SPIRIT MATERIAL

Brazil: several man-biting ♀♀, 15♀♀ (reared), 12♂♂ (reared), numerous pupae and larvae, **Roraima State**, Catrimani mission, R. Catrimani, 9.i.1977 (*A.J. Shelley*) & 12.i.1979, B.M.1979–580, 13 & 14.vii.1984 (at intervals between 06.30 & 19.00 hrs) (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting♀, mission post, R. Auaris, 29.iii.1977, B.M.1979–580 (*R.R. Pinger*), (BMNH); 1 pupa, 10 larvae, Mucajaí, 20.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), several pupae, mission post, R. Mucajaí, Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), several pupae, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A Luna Dias*), (BMNH); 1♂, R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), few pupae, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*), (BMNH); 8♀♀ (reared; 4 without associated pupal exuviae), 9♂♂ (reared; 5 without associated pupal exuviae), several pupae, 3 larvae, northern perimeter road, R. Agua Preto, 29.iv.1979, B.M.1979–580 (*A.J. Shelley*), 18.xi.1980 (*A.J. Shelley*), (BMNH); 5♂♂ (reared), Vila Pereira, R. Surumu, 25–27.xi.1980, 11.viii.1984 (*A.J. Shelley*), (BMNH); 12 man-biting♀♀, **Amazonas State**, R. Ituxi, v.1978, B.M.1979–580 (*D. Roberts*), (BMNH); 1 exuviae, **Mato Grosso State**, R. Aripuanã, 29.vi.1978, B.M.1979–580 (*J.D. Charlwood*), (BMNH); 1♀ (reared), **Federal District**, Córrego Papuda on DF 18 before R. São Bartolomeu, 18.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), Brasilia, under bridge on highway DF 6, R. São Bartolomeu, 12.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 2♀♀ (reared), R. Palmeiras (Maranhão), 7.ix.1975, B.M.1979–580 (*A.J. Shelley*), 5.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH).

Argentina: 16 pupae, 11 larvae, **Apartamento de la Sala**, El Ray, 20.x.1973 (*collector not stated*), (BMNH).

Ecuador: 1 man-biting ♀, **Esmeraldas Province**, San Miguel de Cayapa, R. Cayapa, 18–21.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀, San Miguel de Cayapa, 28–30.vi.1980 (*M.E. Arzube*), (BMNH); 1 man-biting ♀, 1♂ (reared), 4 pupae, 1 exuviae, San Miguel de Cayapa, R. San Miguel, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1

man-biting ♀, San Miguel de Cayapa, Estero Hacha, 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 3♂♂ (1 reared), 2 exuviae, R. Cayapa, Agua Blanca, 15.vii.1986 (*P. Beech*) & 28.xi.1984 (15.28 hrs) (*M.L. Kuns*), (BMNH); several man-biting ♀♀, Calle Mansa, R. Cayapa, 22.ix.1984 (13.05 hrs) (*M.L. Kuns*), (BMNH); 11 man-biting ♀♀, 10♀♀, Calle Mansa, R. Cayapa, Tienda Umberto Quintero, 22.xi.1984 (12.46 & 12.55 hrs) (*M.L. Kuns*), (BMNH); 2 pupae, Calle Mansa, R. Cayapa, (1 hr above San Miguel by motorized canoe), 27.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), 2 larvae, Calle Mansa, R. Grande (Cayapa), 27.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), R. Grande (Cayapa), Viruela, 24.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2 pupae, 1 exuviae, 2 larvae, R. Sapallo Grande, 4km above Sapallo Grande mission, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 19 man-biting ♀♀, 1♂ (reared), Tumbaviro, R. Sapallo Grande, 24.v. & 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 larva, Naranjal (R. Canandé), 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 12 man-biting ♀♀, 5♀♀ (reared), 2♂♂ (mass reared), 1 pupa, several larvae, Naranjal (R. Canandé), R. Canandé, 25.ix.1983, 24.vi.1985 & 1 & 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); numerous man-biting ♀♀, 10♀♀ (9 reared; 2 without associated pupal exuviae), 3♂♂ (reared), 5 pupae, several larvae, Naranjal (R. Canandé), R. Naranjal, 23.vi.1985 & 3.vi.1988 (*A.J. Shelley & M.Arzube*), (BMNH); 2 man-biting ♀♀, few pupae and exuviae, Naranjal, R. Aguas Negras, 25.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 7 man-biting ♀♀, Naranjal (R. Canandé), Calle Mansa, riachuelo, 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); numerous man-biting ♀♀, 2♀♀ (mass reared), 1♂ (reared but without associated pupal exuviae), 4 pupae, 15 larvae, Naranjal (R. Canandé), nuns' house, 25.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 5♀♀ (2 reared; 3 mass reared), 1♂ (reared), several pupae and exuviae, 18 larvae, Naranjal (R. Canandé), riachuelo, 25.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 8 man-biting ♀♀, 1♀ (reared), 1♂ (reared), 5 pupae, 1 exuviae, several larvae, Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Salazar, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 10 man-biting ♀♀, 1♂ (reared), 7 pupae, 1 exuviae, 2 larvae, Santo Domingo-Esmeraldas road, road to Puerto Quito, near Concordia, R. Caoni, 24.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 3 man-biting ♀♀, 1♀ (reared), 2♂♂ (reared), 9 pupae, 6 exuviae, several larvae, Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Blanco, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 4 man-biting ♀♀, Santo Domingo-Esmeraldas road, R. Miringo, 24.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 1♂ (reared), 3 exuviae, Santo Domingo-Esmeraldas road, 20m, R. Tabuchi, 26.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 pupae, Quinindé-Esmeraldas road, R. Sapotal, 26.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 6♀♀ (mass reared), few pupae & exuviae, 40m, R. Tasechi, 27.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 7♀♀ (reared), 5♂♂ (reared), numerous pupae & exuviae, few larvae, **Cotopaxi Province**, Quevedo-La Maná-Pilaló road, 240m, R. San Pablo, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), 1 larva, Quevedo-La Maná-Pilaló road, 260m, bridge over R. San Pablo, riachuelo, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 6♀♀ (2 reared), 1♂ (reared), numerous pupae & exuviae, few larvae, **Guayas Province**, Naranjal-Machala road, via Cooperativa 11 deAgosto, 80m, R. Bucay, 19.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, **Imbabura Province**, Salinas road, 20km North of Ibarra, bridge over R. Tahuando, 8.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 1 man-biting ♀, near Salinas, Hacienda La Condal, irrigation canal, 8.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, 8 pupae, 2 larvae, Salinas-Lita road, 45km from Ibarra, San Juan del Hacha, R. Mira, 11.ix.1983 (*A.J. Shelley & M.Arzube*, (BMNH); 4♀♀, 4 pupae, 13 larvae, Salinas-Lita road, 40km from Ibarra, un-named stream, 11.ix.1983, (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, 17km south of Juncal, on Ibarra road, Engeño Tababuelo, R. Chota, 7.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, 15km south of Juncal, on Ibarra road, bridge Puente Al Angel, R. Chota, 7.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, Salinas-Lita road, R. Palacara, 9.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); several man-biting ♀♀, Lita, junction of R. Mira & R. Lita, 12.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, **Los Ríos Province**, Babahoyo-Montalvo road, 60m, R. Cristal, 10.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, 5 pupae, 14 larvae, **Manabi Province**, Santo Domingo-El Carmen road, Km 40, 2km past El Carmen, R. Suma, 7.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, **Napo Province**, near Lago Agrio, Posto 19, R. Tarapa, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), few pupae, exuviae & larvae, near Lago Agrio, border with Colombia, 20km from Texaco base, R. San Miguel, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 9 man-biting ♀♀, 3♀♀ (reared), 2♂♂ (reared), several pupae & exuviae, numerous larvae, near Lago Agrio, R. Aguarico, Dureno, 13.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 19 man-biting ♀♀, 27♀♀ (18 reared; 9 mass reared), 13♂♂ (9 reared; 4 mass reared), numerous pupae, exuviae & larvae, near Lago Agrio, 4km from Texaco base, R. Aguarico, 10.xii.1982 (*A.J. Shelley & M.Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), S.W. Coca, Loreto, 1986 (*P. Beech*), (BMNH); 2 man-biting ♀♀, **Pichincha Province**, Quito-Santo Domingo road, 640m, R. Lelia, 29.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH).

Mexico: 5♀♀, 4♂♂, **Veracruz**, Cordoba, 15.ii.1948, B.M.1948–401 (*I. Cordova*), (BMNH).

Panama: 1♀ (reared), **Darien Province**, Morti, 10.i.1985 (*J.L. Petersen*), (BMNH).

Venezuela: numerous man-biting ♀♀, **Monagas State**, Caripe area, El Rincón, 7.v.1961 (*D.J. Lewis*), (BMNH); several man and donkey-biting ♀♀, El Quebracho (near Caripe), 7.v.1961, (*D.J. Lewis*), (BMNH).

Simulium (Psaroniocompsa) quadrifidum Lutz

PINNED

Brazil: 4♀♀ (3 reared), 8♂♂ (reared), **Roraima State**, R. Mucajaí, Igarapé Coroconaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH, IOC); 10♀♀ (reared; one with head on slide), 11♂♂ (reared), mission post, R. Auaris, 7 & 9.vii.1976, B.M.1979–580 (*A.J. Shelley*) & 30.iii.1977, B.M.1979–580

(*R.R. Pinger*), (BMNH, 1OC); 1♀ (reared), 5♂♂ (reared), mission post, R. Auaris, Igarapé Hutumati, 7.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), Surucucus, Dalem (in river), 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 8♀♀ (reared), 1♂ (reared), near Caracaraí, R. Branco, stream by road to Bem Querer, 20.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 4♂♂ (reared), 1 exuviae, stream on road to Bem Querer, 29.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 2♀♀ (reared), near Caracaraí, on track to Bem Querer, stream at Km 15, 19.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Boa Vista-Sta. Elena road, R. Surumu, 20.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 2♀♀ (reared), 3♂♂ (reared), Boa Vista-Sta. Elena road, Boca da Mata, Igarapé Cunaen, 28.xi.1980 & 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), northern perimeter road, stream at Km 211, 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 2♂♂ (reared), northern perimeter road, stream at Km 96, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), 1 pupal exuviae (♀), northern perimeter road, stream at Km 38, 19.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), near Normandia, Fazenda Cariri, R. Maú, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀ (reared), 5♂♂ (reared), 2 pupal exuviae, **Amazonas State**, mission post, R. Toototobi, 26.ii.1976, 11.xii.1976 & 3.xii.1977, B.M.1979–580 (*A.J. Shelley*) & 14.viii.1976 (*R.R. Pinger*), (BMNH, 1OC); 14♀♀ (reared), 11♂♂ (reared), 1 pupal exuviae, Capacini, R. Purus, 25 & 26.ix.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4♀♀ (reared), 2♂♂ (reared), R. Purus, Igarapé Escondido, 17.xi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), Feijoal, R. Solimões, Igarapé São Jorge, 3.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), Feijoal, R. Solimões, stream, 3.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 7♀♀ (reared), 3♂♂ (reared), Tefé, R. Solomões, 22.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 12♀♀ (reared), 9♂♂ (reared), Tefé, Igarapé Bauana, 10.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), near Manaus, road to Ponta Negra, Km 17, Igarapé Taramazinho, 28.x.1976, B.M.1979–580 (*R.R. Pinger*), (BMNH); 5♂♂ (reared), near Manaus, Igarapé Taruma, 2.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), **Rondonia State**, 76km from Porto Velho, Igarapé Caracol, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), R. Jacy Parana, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 1 man-biting ♀, **Esmeraldas Province**, San Miguel de Cayapa, R. Cayapa, 18–21.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), 4km from San Lourenço, on Tululbi road, R. Nadadeiro, 14.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Santo Domingo-Esmeraldas road, R. Savalito, 23.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀ (3 with associated pupal exuviae), **Napo Province**, near Lago Agrio, Posto 19, R. Tarapa, 9.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 3♂♂ (reared), near Lago Agrio, R. San Isidro, 22.v.1988, (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Tena, 6km from Tena on Tena-Muiuna road, stream, 7.vi.1985, (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), **Pastaza Province**, Tena-Puyo road, near Manantial, 920m, stream Huamayaca, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), Tena-Puyo road, about 920m, tributary of stream Huamayacu, 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH).

Slide mounted

Brazil: 2♀♀ (1 head only), 2 pupal exuviae, **Roraima State**, mission post, R. Auaris, 7 & 9.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀, 3♂♂ (reared), mission post, R. Auaris, Igarapé, 9.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀, mission post, R. Mucajaí, 25.vii.84 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 2♂♂ (reared), 2 larvae, near mission post, R. Mucajaí, Igarapé Coroconaí, 6.i.1977 (*A.J. Shelley*) & 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), near Caracaraí, R. Branco, stream 1km before R. Branco, 20.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Igarapé Cunaen, 28.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀ (reared), 6♂♂ (reared), **Amazonas State**, Tefé, Igarapé Bauana, 10.x.1978 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 7♀♀ (reared), 3♂♂ (reared), 3 larvae, R. Purus, Igarapé Escondido, 17.xi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 1♂ (reared), R. Purus, Igarapé Escondido, Lagoa Bom Lugar, 17.xi.1977 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 7 larvae, Capacini, R. Purus, 25 & 26.ix.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), 4 larvae, Tefé, R. Solimoes, Igarapé Curupira, 22.vii.1976 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), 2 larvae, mission post, R. Toototobi, 26.ii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), R. Toototobi, 3.xii.1977 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), 1♂ (reared), 4 larvae, **Rondonia State**, R. Jacy Parana, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), near Porto Velho, R. Jacy Parana, 16.x.1978 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), 2 larvae, 76km from Porto Velho, Igarapé Caracol, 16.x.1978 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 1♀ (reared), **Pastaza Province**, Tena-Puyo road, 920m, riachuelo Huamayaca, 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH).

Guyana (British Guiana): 3 pupae, Mazaruni, high forest, 'Brown Water' Creek, 16.ix.1937 (*J. Smart*), (BMNH).

Surinam: 1 pupa [abdomen only], Lawa River, Aseli Kamp, forest creek, 4°17'N 54°23'W, 15.xi.1979 (*J.E. Hudson*), (BMNH).

Spirit material

Brazil: 8 pupae, 2 pupal exuviae, several larvae, **Roraima State**, mission post, R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), 2 pupae, 2 pupal exuviae, 6 larvae, Auaris mission, Igarapé, 9.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), mission post, R. Auaris, Igarapé Hutumati, 7.xii.1986, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 2 pupae, 3 pupal exuviae, 2 larvae, mission post, R. Mucajaí, 25.vii.1984, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), several pupae, exuviae & larvae, near mission post, R. Mucajaí, Igarapé Coroconaí, 6.i.1977

& 21.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 7 larvae, Mucajaí, Igarapé downriver from Coroconaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), R. Auau, 2.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♂♂ (reared), 1 pupa, northern perimeter road, stream at Km 211, 12.i.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1 pupal exuviae, 5 larvae, northern perimeter road, Km 211, FUNAI Post, 12.i.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), northern perimeter road, stream at Km 38, 19.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), northern perimeter road, R. Ajaraní 2, 16.i.1979 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 7♂♂ (reared), 1 pupal exuviae, near Caracaraí, R. Branco, stream at Km 15, on track to Bem Querer, rapids, 19.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, 5♂ (4 reared), 3 pupae, 15 pupal exuviae, 9 larvae, near Caracaraí, R. Branco, stream at Km 15, Bem Querer road, 20.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), Cachoeira Bem Querer, Igarapé na estrada, 20.xi.1980 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), Igarapé Cunaen, 28.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), near BV8, Igarapé Avila, 29.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), several mass reared & ♂♂, numerous pupae, few larvae, Boa Vista-Sta. Helena road, Boca da Mata, Igarapé Cunaen, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀, 5♂♂, 3 pupae, 6 exuviae, near Boa Vista, Igarapé Cachorro, 28.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀ (3 reared), 10♂♂ (9 reared; 3 with associated pupal exuviae), several pupae and exuviae, Cantar-Boa Vista road, un-named stream, 28.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), 5 pupae, 15 pupal exuviae, 8 larvae, **Amazonas State**, mission post, R. Toototobi, 26.ii.1976. B.M.1979–580 (*A.J. Shelley*), (BMNH); 2 pupae, 7 pupal exuviae, 23 larvae, R. Toototobi, 11.xii.1976 & 1.xii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3 pupal exuviae, 10 larvae, R. Toototobi, Igarapé near Plinio, 25.x.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀, 2♂♂, 7 pupae, 2 pupal exuviae, Capacini, R. Purus, 18.x.1973 & 25.ix.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH): few larvae, Capacini, R. Purus, tributary stream, 18.x.1973, (*A.J. Shelley*), (BMNH); 1♀ (reared), 2♂♂ (reared), 10 pupae, 1 pupal exuviae, R. Purus, Igarapé Escondido, 17.xi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 2♂♂ (reared), near Manaus, Igarapé Taruma, 2.v.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 1♀ (reared), several pupae, **Rondonia State**, near Porto Velho, Igarapé Bate Estaca, 14.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 4 pupae, 4 pupal exuviae, 3 larvae, 76km from Porto Velho, Igarapé Caracol, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 3♀♀ (reared), 1♂, 18 pupae, **Pastaza Province**, Tena-Puyo road, 920m, R. Huamayacu, 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH).

Surinam: 6 pupae, several larvae, Aseli Kemp, R. Iawa, 4°17'N 54°23'W, 15.xi.1979 (*J.E. Hudson*), (BMNH).

Simulium (Psaroniocompsa) cauchense Floch & Abonnenc

Type material

French Guiana: 1♂ (reared) LECTOTYPE (slide no.742), 1♀ (reared) PARALECTOTYPE (slide no.743), Caux, 6.vi.1946 (*collector not stated*), (IP).

Pinned

Brazil: 10♀♀ (reared), 9♂♂ (reared), 2 pupal exuviae (♂), **Roraima State**, mission post (Posta Meva), R. Auaris, 4°8'N 64°29'W, 7.vii.1976, 30 & 31.iii.1977, B.M.1979–580 (*R. R. Pinger*) & 9 & 7.vii.1976, B.M.1979–580 (*A.J. Shelley*) & 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), near mission post, R. Mucajaí, Igarapé Coroconaí, 6.i.1977, B.M.1979–580 (*A. J. Shelley*), (BMNH); 7♀♀ (reared), 8♂♂ (7 reared), 1 pupal exuviae, Boa Vista-Sta. Helena road, Boca da Mata, Igarapé Cunaen, 20.iv.1982 (*A. P. A. Luna Dias & R. Malaguti*), 28.xi.1980 & 11.viii.1984 (*A.J. Shelley & A. P. A. Luna Dias*), (BMNH, IOC); 1♂ (reared), Boa Vista-Sta. Helena road, R. Surumu, 20.iv.1982 (*A. P. A. Luna Dias & R. Malaguti*), (BMNH); 1♀ (reared), R. Preto, tributary of R. Ajaraní, 28–29.iv.1979 (*R. W. Crosskey & A. J. Shelley*), (BMNH); 1♀ (reared), northern perimeter road, R. Agua Preta, 18.xi.1980 (*A. J. Shelley & A. P. A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), Surucucus, Dalem (in river), 11.xii. 1986, (*A. J. Shelley & A. P. A. Luna Dias*), (BMNH).

Guyana: 1♀, Rupununi, Orinduik Falls, 22.iii.70 (*J.B. Davies*), (BMNH).

Slide mounted

Brazil: 2♀♀ (reared), **Roraima State**, near mission post, R. Mucajaí, Igarapé Coroconaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), mission post, R. Auaris, Igarapé, 9.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (dissected from pupa), 2 pupae (1 abdomen only), R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), Surucucus, Dalem, 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 1♂ (reared), 7 larvae, Boa Vista-Santa Helena road, Igarapé Cunaen, 28.xi.1980 & 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*) & 20.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH).

Spirit material

Brazil: 2♂♂ (reared), few pupal exuviae, several larvae, **Roraima State**, Boa Vista-Sta. Helena road, Boca da Mata, Igarapé Cunaen, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 3♂♂ (2 reared), 6 pupae, 2 pupal exuviae, Igarapé Cunaen, 2.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*) & 28.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, mission post, R. Mucajaí, Igarapé Coroconaí, 6.i.1977 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), few pupae, several pupal exuviae, mission post, R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 5♂♂ (reared), R. Auaris, Igarapé by mission, 9.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), **Amapá State**, Oiapoque-Macapá road, Km 93, R. Uaça, 17.xii.1994 (*S. Luz*), (BMNH).

Guyana: 1♀ (reared), 1♂ (reared), 3 pupae, 2 pupal

exuviae, mouth of R. Tumong, 1.xii.1970 (*J.B. Davies*), (BMNH); 1♀ (reared but without associated pupal exuviae), 1♂ (reared but without associated pupal exuviae), 5 pupal exuviae, Itabec crossing, R. Tumong, 2.xii.70 (*J.B. Davies*), (BMNH).

Simulium (Psaroniocompsa) oyapockense

TYPE MATERIAL

French Guiana: 1♀ (reared) LECTOTYPE (slide no.732), 1♂ (reared) PARALECTOTYPE (slide no.731), Cafésoca, 1.vi.1946 (*E. Abonnenc*), (IP).

PINNED

Brazil: 9 man-biting ♀♀, 9♀♀ (reared), 1♂ (reared), **Roraima State**, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 1♂ (reared), Cachoeira, R. Cauamé, 19.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 11 man-biting ♀♀, near Caracaraí, R. Branco [=Cachoeira Bem Querer], 29.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 17 man-biting ♀♀, 12♀♀ (reared), 8♂♂ (reared), Cachoeira Bem Querer, R. Branco, 16.i.1979, B.M.1979–580, 19 & 20.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 13 man-biting ♀♀, 3♀♀ (reared), 3♂♂ (reared), 2 pupae, R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3 man-biting ♀♀, 2♂♂ (reared), near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley & A.P.A.Luna Dias*), (BMNH); 2♀♀ (reared), 1♂ (reared), Serra da Lua, R. Urubu, 26.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 5♀♀ (4 reared), 3♂♂ (1 reared), **Amazonas State**, R. Ituxi, Igarapé do Paraná, 30.ix.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 43 man-biting ♀♀, 1♀ (reared), 1♂ (reared), mission post, R. Toototobi, 24.x.1976, 11.xii.1976, 24.viii.1977, 1.xi.1977, 3.xii.1977, B.M.1979–580 (*A.J. Shelley*) & 15.viii.1976, 25.x.1976, (*R.R. Pinger*), (BMNH); 2♀♀ (1 reared), **Amapá State**, Maripa, R. Oyapock, Cachoeira Cafésoca, 29.v.1982 (*A.P.A. Luna Dias*), (BMNH); 2♀♀ (1 reared), Maripa Falls, 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 14 man-biting ♀♀, 3♀♀ (reared), 3♂♂ (reared), **Rondonia State**, R. Jacy Parana, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), Cachoeira Teotonio, R. Madeira, 10.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Guyana: 2♂♂, Lethem, R.Takutu, Bon Fin, 13.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH).

Venezuela: 3♀♀ (1 with pupal exuviae on slide), 1♂ (reared), **Amazonas State**, Siquita, 31.vii.1982 (*J.R. Pérez*), (BMNH); 2♂♂ (reared; 1 pupal exuviae on slide), R. Negro, San Carlos (*J.R. Pérez*), (BMNH); 1♀ (reared), 3♂♂ (reared), 1 pupal exuviae, **Bolivar State**, R. Cuyuni, between Guyana and Anacoco, 90 mts, B.M.1969–676 (*J. Ramírez*) (BMNH); 1♀ (reared), **Guarico State**, Barbacoas, no date (*collector not stated*), (BMNH).

HYDROCARBONS

Brazil: 8 man-biting ♀♀, **Roraima State**, Cachoeira Bem Querer, xi.1986 (*A.J. Shelley*), (BMNH); 9 man-biting ♀♀, Parimiu, xi.1986 (*A.J. Shelley*), (BMNH).

SLIDE MOUNTED

Brazil: 4♀♀ (3 reared; 1 genitalia only), 6♂♂ (reared; 1 missing genitalia; 1 dissected from pupa), 2 pupal exuviae, 1 larva (ex cytology), **Roraima State**, Cachoeira Bem Querer, R. Branco, 16.i.1979, 4.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*) & 20.xi.1980 (*A.J. Shelley*), (BMNH); 6 man-biting ♀♀, 2♀♀ (reared), 2♂♂ (reared), R. Uraricoera, (Boa Vista-Venezuela road), 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 9 man-biting ♀♀, **Amazonas State**, R. Toototobi, 24.x.1976, 3.xii.1977 (*A.J. Shelley*), (BMNH); 3 man-biting ♀♀, mission post, R. Toototobi, 11.xi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 3♂♂ (reared), R. Ituxi, Igarapé do Paraná, 30.ix.1976 (*A.J. Shelley*), (BMNH); 2♀♀ (1 reared), 3♂♂ (1 reared, 1 with genitalia only), 5 pupal exuviae (1 with abdomen only), **Amapá State**, Maripa, R. Oyapock, Cachoeira Cafésoca, 29.v.1982 (*A.P.A. Luna Dias*), (BMNH); 1♀ (dissected from pupa), 1♂ (dissected from pupa), R. Oyapock, Maripa Falls, 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, 2♀♀ (reared), 2♂♂ (reared), 6 larvae, **Rondonia State**, R. Jacy Parana, (95km from Porto Velho), 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), Cachoeira Teotônio-R. Madeira, Porto Velho, 10.x.1978 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

SPIRIT MATERIAL

Brazil: numerous man-biting ♀♀, 60♀♀ (reared; 2 without associated pupal exuviae; 1 with pupal exuviae on slide), 70♂♂ (reared), 2 pupal exuviae, several pupae, several larvae, **Roraima State**, Cachoeira Bem Querer, R. Branco, 19 & 20.xi.1980 (*A.J. Shelley*) & 16.i.1979, 4.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous pupae, near Caracaraí, R. Branco [=Bem Querer], 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous man-biting ♀♀, 1♀ (reared), 1♂ (reared), 4 pupal exuviae, R. Uraricoera, (BoaVista-Venezuela road), 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*) & 16.viii.1977 (*M.A.P. Moraes*), (BMNH); numerous man-biting ♀♀, 1 pupal exuviae, **Amazonas State**, mission post, R. Toototobi, 26.ii.1976, 11.xii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); numerous man-biting ♀♀, R. Toototobi, tributary of R. Demini, 1975 (*A.J. Shelley*), (BMNH); 1♀ (reared), R. Ituxi, Igarapé do Paraná, 30.ix.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), several pupae, **Amapá State**, Maripa, R. Oyapock, Cachoeira Cafésoca, 29.v.1982 (*A.P.A. Luna Dias*), (BMNH); 3 pupae, 3 larvae, R. Oyapock, Maripa Falls, 21.v.1992 (*C. Lowry & A.P.A Luna Dias*), (BMNH); numerous man-biting ♀♀, 7♀♀ (6 reared), 7 pupal exuviae, 8 larvae, **Rondonia State**, R. Jacy Parana, 16.x.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Simulium (Psaroniocompsa) roraimense Nunes de Mello

PINNED

Brazil: 28 man-biting ♀♀, 50 ♀♀ (reared), 31♂♂ (reared) **Roraima State**, Cachoeira, R. Cauamé, 19.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*) & 20, 21 & 22.xi.1980, 12.viii.1984, 2.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*) & 29.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 91

man-biting ♀♀, 9♀♀ (reared), 6♂♂ (reared), Catrimani mission, R. Catrimani, 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*) & 9.i.1977 (*A.J. Shelley*) & 11–12.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♂♂ (reared), near Normandia, Fazenda Cariri, R. Maú, 2 & 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♂♂ (reared), near Bonfin, R. Arraia, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), northern perimeter road, R. Ajaraní 1, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

HYDROCARBONS

Brazil: 26 man-biting ♀♀, **Roraima State**, Cachoeira, R. Cauamé, 2.xii.1986 (*A.J. Shelley*), (BMNH); 16 man-biting ♀♀, Parimiu, xi.1986 (*A.J. Shelley*), (BMNH).

SLIDE MOUNTED

Brazil: 1 man-biting ♀, 3♀♀ (reared), 5♂♂ (reared), 1 pupal exuviae, 9 larvae (1 ex cytology), **Roraima State**, Cachoeira, R. Cauamé, 19.i.1979, 22.xi.1980, 12.viii.1984, 2.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*) & 25.iv.1979 (*A.J. Shelley*), (BMNH); 27 man-biting ♀♀, 5♂♂ (reared), Catrimani mission, R. Catrimani, 9.i.1977 (*A.J. Shelley*) & 14.vii.1984 (between the hours of 09.00–10.00, 14.00–15.00, 16.00–17.00) (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*) & (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), northern perimeter road, R. Ajaraní 1, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♂♂ (reared), near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

SPIRIT MATERIAL

Brazil: numerous man-biting ♀♀, 24♀♀ (reared; 1 pupal exuviae slide mounted), 24♂♂ (reared), numerous pupae, several larvae, **Roraima State**, Cachoeira, R. Cauamé, 19.i.1979, 25.iv.1979, 22.xi.1980 (*A.J. Shelley*) & 10.vii.1984, 12.viii.1984, 2.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♂♂ (reared), near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*), (BMNH); numerous man-biting ♀♀ (many caught at recorded half hourly or hourly intervals during the day between 06.30–19.00), 2 pupae, 5 pupal exuviae, Catrimani mission, Catrimani, 12.i.1979, 13 & 14.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), 9.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH).

Specimens identified as *S. oyapockense/ roraimense*

PINNED

Brazil: 56 man-biting ♀♀, 1♀ (reared), **Roraima State**, near Boa Vista, R. Cauamé, 25.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*) & 4.iv.1976, B.M.1979–580 (*R.R. Pinger*) & 16.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 23 man-biting ♀♀, mission post, R. Mucajaí, 5.i.1977, 17.i.1979 & 22.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 12 man-biting ♀♀, near Normandia, Fazenda Cariri, R. Maú, 2 & 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 13 man-biting ♀♀, near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3 man-biting ♀♀, near Boa Vista, R. Murupu, 25.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*) & 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 7 man-biting ♀♀, Boa Vista-Caracaraí, 9km before Vila Nova, 20.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3 man-biting ♀♀, VistaAlegre, R. Branco, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting ♀♀, mission post, R. Uraricoera, 16.viii.1977 (*M.A.P. Moraes*), (BMNH); 19 man-biting ♀♀, Vila Pereira, R. Surumu, 25.xi.1980 (*A.J. Shelley & A.P. Luna Dias*), (BMNH); 3 man-biting ♀♀, Posto da Fronteira, Venezuela-Guiana, R. Maú, 1.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♀, northern perimeter road, R. Ajaraní 1, 28.iv.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀, locality 6, R. Repartimento, 29.iv.1979, B.M.1979–258 (*A.J. Shelley & R.W. Crosskey*), (BMNH); 2 pupae in capsule containing glycerin, Boa Vista-Sta. Helena road, near Igarapé Cunaén, 11.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3 man-biting ♀♀, **Amazonas State**, Igarapé Ira, tributary of R. Vaupes, 0°3'N 68°30'W, 1.vi.1977 (*J. Arias*), (BMNH); 11 man-biting ♀♀, Igarapé Tiquié, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH); 12 man-biting ♀♀, **Pará State**, Marabá, 15.xii.1976, B.M.1979–580 (*L. Hoch*), (BMNH); 1 man-biting ♀, Transamazonica road, Maraba-Altamira, Km 360, near R. Anapu, 8.iv.1976, B.M.1979–580 (*W. Arouck*), (BMNH); 1 man-biting ♀, Uruá, Parque Nacional da Amazonia, 1.ix.1978, B.M.1979–580 (*L.A. Lacey*), (BMNH); 67 man-biting ♀♀, Uruá, R. Tapajos, 56°19'W 54°33'S, 29.viii.1979, B.M.1979–580 (*L.A. Lacey*), (BMNH).

Colombia: 5 man-biting ♀♀, Comis, Vaupes, Caño Cuduyari, Santa Marta, near Mitu, 18.i.1978 (*M.A. Tidwell*), (BMNH); 5♀♀, Mitu, 1.i.1968 (*C.J. Marinkelle*), (BMNH).

Ecuador: 42 man-biting ♀♀, 20 horse-biting ♀♀, 10♀♀ (reared), 9♂♂ (8 reared), **Manabi Province**, Portoviejo-Poçahonda road, Pachinche, R. Portoviejo, 6.xii.1984 (*M. Arzube*), (BMNH); 2 man-biting ♀♀, 50–60m, R. Daule, 8.xii.1984 (*M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), R. San Placido, 8.xii.1984 (*M. Arzube*), (BMNH).

Guyana: 11♀♀, Thanimi Creek, 400 miles from coast, 1908 (*N.S. Wise*), (BMNH); 2♀♀, no date, B.M.1939–586 (*Wise*), (BMNH); 3 man-biting ♀♀, Tukeit on the Potaro River, 31.viii.–10.ix.1937, B.M.1937–776 (*Richards & Smart*), (BMNH); 6 biting ♀♀, Warratuk Fall (rapid) on the Potaro River, 31.viii.1937, B.M.1937–776 (*Richards & Smart*), (BMNH); 2 man-biting ♀♀, 1♀, on the Savannah at Kaieteur Falls on the Potaro River, 1–6.ix.1937, B.M.1937–776 (*Richards & Smart*), (BMNH); 2♀♀, Rupununi District, R. Ireng, Orinduik Falls, 11.viii.1957 (*R. McConnell*), (BMNH); 117 man-biting ♀♀, Orinduque, R. Ireng, 4°44'N 60°2'W, 23.iii.1970, (*J.B. Davies*), (BMNH); 41 man-biting ♀♀, Orinduik, creek near D.C.'s house, 4°42'N 60°1'W, 3.xii.1970 (*J.B. Davies*), (BMNH); 8 man-biting ♀♀, Orinduik Falls, 24.ii.1970 (*J.B. Davies*), (BMNH); 3 man-biting ♀♀, R. Tumong, 24.iii.1970 (*J.B. Davies*), (BMNH); 37 man-biting ♀♀, Kurukabaru Trial, R. Tumong, 4°47'N 59°58'W, 3.xii.1970 (*J.B. Davies*), (BMNH); 17 man-biting ♀♀, R. Tumong, Lower Falls, 2.xii.1970 (*J.B. Davies*), (BMNH); 17 man-biting ♀♀, Kato, R. Chiung, 4°38'N 59°52'W, 2–7.xii.1970 (*J.B. Davies*), (BMNH); 20♀♀, Apoteri, R. Esseq, ix–x.1926 (*L.D. Cleare,*

Jr.), (BMNH); 5♀♀, Karamambu, R. Rupununi, viii.1959 (*E. McTurk*), (BMNH); 2♀♀, Lethem, R. Takutu, Bon Fin, 13.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀, Lethem, 15.viii.1975 (*E.S. Tikasingh*), (BMNH); 7 man-biting ♀♀, Lethem Hospital, R. Takutu, 21.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 6 man-biting ♀♀, Lethem, Rest Home, R. Takutu, 14.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2 man-biting ♀♀, Dadanawa, R. Rupununi, 19.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH).

HYDROCARBONS

Brazil: 1 man-biting ♀, **Roraima State**, Parimiu, xi.1986 (*A.J. Shelley*), (BMNH).

SLIDE MOUNTED

Brazil: 6♀♀ (reared), **Roraima State**, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*) & (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting♀♀, mission post, R. Mucajaí, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, **Amazonas State**, Marabá-Altamira, near River Anapu, Km 360, Transamazonica road, 8.iv.1976 (*W. Arouck*), (BMNH); 6 man-biting♀♀, Igarapé Ira, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH); 1 man-biting ♀, **Pará State**, Marabá, 15.xii.1976 (*L. Hoch*), (BMNH).

Ecuador: 1 man-biting ♀, 1♂, **Manabi Province**, Portoviejo-Poçahonda road, R. Portoviejo Pachinche, 6.xii.1984 (*M. Arzube*), (BMNH).

SPIRIT MATERIAL

Brazil: 9 man-biting♀♀, **Roraima State**, 9km after Vila Nova on BR 174 (3km from R. Branco), 20.xi.1980 (*A.J. Shelley*), (BMNH); numerous man-biting ♀♀, Vista Alegre, R. Branco, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 10 man-biting♀♀, R. Mucajaí, 17.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous man-biting♀♀, mission post, R. Mucajaí, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2 pupae, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, mission post, Auaris, 29.iii.1977, B.M.1979–580 (*R.R. Pinger*), (BMNH); 2 man-biting ♀♀, near Boa Vista, R. Cauamé, B.M.1979–580, 16.viii.1977, 12.iv.1979 (*A.J. Shelley*), (BMNH); 4♀♀ (reared), 4 pupae, near Bonfim, R. Arraia, 3.xii.1980 (*A.J. Shelley*), (BMNH); 1♀ (reared), Normandia, Igarapé Inamarú, 3.xii.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting♀♀, Vila Pereira, R. Surumu, 26.xi.1980 (*A.J. Shelley*), (BMNH); numerous man-biting ♀♀, several pupae, near Normandia, Fazenda Cariri, R. Maú, 3.xii.1980 (*A.J. Shelley*), (BMNH); 11 man-biting ♀♀, Aldeia Canta Galo, R. Cotingo, 27.xi.1980 (*A.J. Shelley*), (BMNH); 3 man-biting ♀♀, 1 pupal exuviae, northern perimeter road, R. Ajaraní 1, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀, northern perimeter road, R. Ajaraní 2, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 14 man-biting ♀♀, northern perimeter road, R. Repartimento, 28.iv.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4 man-biting ♀♀, **Amazonas State**, R. Ituxi, v.1978, B.M.1979–580 (*D. Roberts*), (BMNH); numerous man-biting♀♀, Igarapé Tiquié, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH); 5♀♀, **Pará State**, Uruá, R. Tapajos, 12.x.1977 (*B. Ratcliffe*), (BMNH); several man-biting♀♀, Parque Nacional Amazonas, Uruá, R. Tapajos, 1.ix.1978, B.M.1979–580 (*L.A. Lacey*), (BMNH); several man-biting♀♀, Marabá, R. Anapu, 8.iv.1976, B.M.1979–580 (*W. Arouck*), (BMNH).

Ecuador: numerous man-biting ♀♀, 23 horse-biting ♀♀, numerous larvae, **Manabi Province**, Portoviejo-Poçahonda road, Pachinche, R. Portoviejo, 6 & 11.xii.1984 (*M. Arzube*), (BMNH).

Guyana: numerous man-biting ♀♀, Karamambu, R. Rupununi, viii.1959 (*E. McTurk*), (BMNH); 9 man-biting ♀♀, S.A. Province, Lethem, behind Government Rest House, FR4-19, 15.viii.1975 (*E.S. Tikasingh*), (BMNH); numerous man-biting ♀♀, Lethem, Trail X, Takutu River, 4.xi.1970 (*collector not stated*), (BMNH); 3 man-biting ♀♀, R. Takutu, crossing at Bon Fin, 13.i.1975 (*J.B. Davies*), (BMNH); 22 man-biting ♀♀, Orinduik, creek near D.C.'s house, 22 & 24.iii.1970 (*J.B. Davies*), (BMNH); 4 man-biting♀♀, Orinduik, R. Ireng, beach below Idow Falls, 23.iii.1970, (*J.B. Davies*), (BMNH); numerous man-biting ♀♀, Orinduik, R. Ireng, 28.vii.1969, 22.iii.1970 (*J.B. Davies*), (BMNH); 12 man-biting ♀♀, Orinduik, small farm, Gomes shp, 16.iv.1968, (*J. Darlington*), (BMNH); 2 man-biting♀♀, site no.11, 19.ix.1980 (*M.B. Nathan*), (BMNH); 1 man-biting ♀, site no.26, 25.ix.1980 (*M.B. Nathan*), (BMNH).

Simulium (Psaroniocompsa) incrustatum Lutz

TYPE MATERIAL

Brazil: pupa LECTOTYPE, 1♀, 1♂, PARALECTOTYPES, **Minas Gerais**, Mendes, 1910 (*collector not stated*), (IOC).

as *Simulium aequifurcatum* Lutz

Brazil: pupa HOLOTYPE, no collection locality, no date (*collector not stated*), (IOC).

as *Simulium yarzabali* Ramírez Pérez

Venezuela: 2♀♀ (reared, pinned), 1♂ (reared, pinned with abdomen and pupal exuviae on slide), 1 pupal exuviae (on slide), PARATYPES, **Amazonas State**, Dept. Atabapo, Sierra de Parima, 1050m, Mayuwëteri, 20 & 28.iv.1980 (*J. Ramírez Pérez*), (BMNH).

PINNED

Brazil: 15 man-biting ♀♀, 1♀ (reared), **Roraima State**, Surucucus, Dalem, 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting ♀♀, 2♀♀, Serra dos Surucucus, Igarapé do posta do FUNAI, 5.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH, IOC); 2♂♂ (reared), Serra dos Surucucus, Igarapé perto da Missão, 7.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 35 man-biting ♀♀, 5♀♀ (reared), 4♂♂ (reared), mission post, R. Auaris, 7 & 11.vii.1976, B.M.1979–580, 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*) & 4°8'N 64°29'W, 31.iii.1977 (*R.R. Pinger*), (BMNH, IOC); 1 man-biting ♀, **Minas Gerais State**, Lassance, carro, 26.vi.1980 (*A.P.A. Luna Dias & P. Garritano*), (BMNH); 1 man-biting♀, Pirapora, R. São Francisco, 29.vi.1980 (*A.P.A. Luna Dias &*

P. Garritano), (BMNH); 1 man-biting ♀, Corinto, R. das Velhas, 21.vii.1980 (*A.P.A. Luna Dias & P. Garritano*), (BMNH); 4♀♀ (reared), 1♂ (reared), Corinto road (km 70), Fazenda Olaria, (12km from curve 10), Córrego Rocinha, 15.xii.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Corinto road (km 70), Fazenda Cachoeira, (8km from curve 10), Córrego de Caveira, 15.xii.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 2♂♂ (reared), Corinto, R. Cangalha, 2.vii.1980 (*A.P.A. Luna Dias & P. Garritano*), (BMNH); 16 horse-biting ♀♀, 18♀♀ (reared), 11♂♂ (reared), **São Paulo State**, Serra da Bocaina, Fazenda Bonito, 6.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 2♀♀ (1 reared), **Rio de Janeiro**, Tijuca Forest, Córrego Cascatinha, 50m above waterfall, 7.ii.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH, IOC); 1♀ (reared), Xerem, Floresta do IBDF, 0.5km da estrada Registro, 21.ii.1979, B.M.1979–580 (*Travassos & A.J. Shelley*), (BMNH); 1♀ (reared), Xerem, Córrego João Pinto, Floresta do IBDF, 21.ii.1979, B.M.1979–580 (*Travassos & A.J. Shelley*), (BMNH); 9♀♀ (reared), 4♂♂ (reared), **Santa Catarina State**, state boundary on BR 101, R. Sáo João, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), Santa Catarina-Curitiba-Paraná road, Km 20 from state border, R. Pirabeiraba, 17.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Argentina: 1♀ (as *S. opalinifrons*), E.P. Dorado, Salto, Sta. Elena, 8.vii.1965 (*C.G.H.*), (BMNH); 1♀ (reared) (as *S. opalinifrons*), Misiones, Ao. Guavirá, 5km N.E. of Eldorado, 19.vii.1972 (*Coscarón*), (BMNH).

Ecuador: 2 man-biting ♀♀, **Esmeraldas Province**, Naranjal, R. Canandé, 25.ix.1983 (*A.J. Shelley*), (BMNH); 6♀♀ (2 reared), Santo Domingo-Esmeraldas road, R. Miringo, 24.ix.1983 (*M. Arzube & A.J. Shelley*), (BMNH); 9♀♀ (6 reared), 7♂♂ (reared), Santo Domingo-Esmeraldas road, R. Savalito, 24.ix.1983 (*M. Arzube & A.J. Shelley*), (BMNH); 5♀♀ (reared), 3♂♂ (reared), Naranjal (R. Canandé), R. Aguas Negras, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), Naranjal, R. Aguas Negras, 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, 1♀ (reared), **Cotopaxi Province**, Quevedo-La Maná-Pilaló road, near La Maná (after), 240m, R. San Pablo, 8.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 4 man-biting ♀♀, 4♀♀ (reared), 4♂♂ (reared), Quevedo-La Maná-Pilaló road, near La Maná (after), 260m, Recintos Beles, bridge over San Pablo, riachuelo, 8.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 5 man-biting ♀♀, **El Oro Province**, Machala-Naranjal road, R. Bucay, 12.xii.1984 (*M. Arzube*), (BMNH); 2 man-biting ♀♀, Machala-Naranjal road, Canal de Riego, R. Bucay, 12.xii.1984 (*M. Arzube*), (BMNH); 2 man-biting ♀♀, 2♀♀ (reared), **Guayas Province**, Naranjal-Machala road, via Cooperativa 11 Agosto, 50m from R. Bucay, forest stream, 19.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 1 man-biting ♀, Naranjal-Machala road, via Cooperativa 11 Agosto, 80m, R. Bucay, 19.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 3 man-biting ♀♀, **Los Ríos Province**, Babahoyo-Montalvo road, R. Cristal, 10.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, 3♀♀ (reared), 1♂ (reared), **Manabi Province**, Santo Domingo-El Carmen road, 2km past El Carmen, Km 40, R. Sumo, 7.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH).

Trinidad: 1♀, Forest Central Range, xi.1913, B.M.1943–33 (*F.W. Urich*), (BMNH).

SLIDE MATERIAL

Brazil: 5 man-biting ♀♀ (1 head only, remainder pinned), 3 larva, **Roraima State**, mission post, R. Auaris, 7 & 11.vii.1976, B.M.1979–580 (*A.J. Shelley*) & 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*) & 29.iii.1977, B.M.1979–580 (*R.R. Pinger*), (BMNH); 2 man-biting ♀♀, R. Mucajaí, 5.i.1977 (*A. J. Shelley*), (BMNH); 12 man-biting ♀♀, Surucucus, Dalem, 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 pupal exuviae (associated ♂ & ♀ in spirit), Serra dos Surucucus, American mission, Igarapé, 12.v.1982 (*A. P. A. Luna Dias & Regina Malaguti*), (BMNH, IOC); 10 man-biting ♀♀, **Amapá State**, SUCAM Reserve, R. Limão Branco, tributary of Tracajatuba, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH); 1 larva, **Mato Grosso State**, 100km from Rondonpolis (on road to Campo Grande), Cerrado, Córrego Cachoeira, 31.x.1990 (*A.J. Shelley*), (BMNH); 1♂ (reared), **São Paulo**, Serra da Bocaina, 200m before IBDF headquarters, stream, 4.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, 3♀♀ (reared), 2♂♂ (reared), 4 pupal exuviae, 4 larvae, Serra da Bocaina, Fazenda da Bonito, R. Bonito, 5.iv.1978, B.M.1978–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 1♀ (reared), 2♂♂ (reared), Serra da Bocaina, Fazenda da Bonito, Córrego da Mãe d'Agua, 5.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), Serra da Bocaina, Fazenda da Bonito, Cachoeira do Segredinho, 6.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, 1 horse-biting ♀, Serra da Bocaina, Fazenda Bonito, stable, 6.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 1 man-biting ♀, 4♀♀ (reared), 4♂♂ (reared; 1 pupal exuviae missing; 1 dissected from pupa), 4 pupal exuviae, 13 larvae, **Santa Catarina State**, Santa Catarina-Curitiba-Paraná road, Km 20 from state border, R. Pirabeiraba, 17.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 1♂ (reared), 7 larvae, state boundary on BR 101, R. Sáo João, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 8 larvae, 15km from frontier Paraná/Santa Catarina, R. Garuva, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, 1♂ (dissected from pupa), **Espirito Santos State**, 30km from Linharcs, Forest Reserve of Companhia Valc do R. Docc, Córrego Rancho Alto, 28–30.vi.1978, B.M.1979–580 (*M. Aragão, O. Tavares & A.P.A. Luna Dias*), (BMNH).

Ecuador: 4 man-biting ♀♀, 1♀ (reared), 5♂♂ (reared), 3 pupal exuviae, **Esmeraldas Province**, Santo Domingo-Esmeraldas road, R. Savalito, 24.ix.1983 (*M. Arzube & A.J. Shelley*), (BMNH); 4 man-biting ♀♀, Naranjal (R. Canandé), 22.vi.1985 (between 09.00–10.00 hours) & 25.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 3 larvae, R. Agua Negras, 23.vi.1985 (*M. Arzube & A.J. Shelley*), (BMNH); 2♀♀ (reared), 1♂ (reared), **Cotopaxi Province**, Quevedo-La Maná-Pilaló road, 260m, bridge over San Pablo, riachuelo, 8.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 3 larvae, **Guayas Province**, Naranjal-Machala road, via Cooperativa 11 Agosto, 60m, riachuelo, 19.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH); 3 larvae, **Manabi Province**, Santo Domingo-El Carmen road, 2km past El Carmen, Km 40, R. Sumo, 7.vi.1984 (*M. Arzube & A.J. Shelley*), (BMNH).

SPIRIT MATERIAL

Brazil: 3 man-biting ♀♀, **Roraima State**, mission post, R. Auaris, 29.iii.1977, B.M.1979–580 (*R.R. Pinger*), (BMNH); 3 man-biting ♀♀, R. Mucajaí, 5.i.1977, B.M.1979–580 (*A. J. Shelley*), (BMNH); numerous man-biting ♀♀, Surucucus, Dalem, (in river), 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀, Serra dos Surucucus, FUNAI Post, 6.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♂ (reared) Serra dos Surucucus, American mission, Igarapé, 12.v.1982 (*A. P. A. Luna Dias & R. Malaguti*), (BMNH); numerous man-biting ♀♀, **Amapá State**, R. Limão, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH); 1♀ (reared but without associated pupal exuviae), 1♂ (reared but without associated pupal exuviae), numerous pupae, 2 larvae, **São Paulo State**, Serra da Bocaina, Fazenda Bonito, R. Bonito, 5.iv.1978, B.M.1979–580 (*A.J. Shelley*), (BMNH); 25 horse-biting ♀♀, several ♀♀, Serra da Bocaina, Fazenda Bonito, stable, 6.iv.1978, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); several pupae, several larvae, **Sta. Catarina Province**, 15km from Paraná/Sta. Catarina frontier, R. Garuva, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); few pupae, several larvae, Sta. Catarina-Curitiba-Paraná road, Km 20 from state border, R. Pirabeiraba, 17.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 4♂♂ (reared), numerous pupae, state boundary on BR 101, R. São João, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 4 man-biting ♀♀, **Esmeraldas Province**, Naranjal, R. Canandé, 25.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 4 man-biting ♀♀, Naranjal (R. Canandé), 22.vi.1985 (07.00–11.00 hrs), (*A.J. Shelley & M. Arzube*), (BMNH); 7 larvae, Naranjal (R. Canandé), R. Aguas Negras, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀, Santo Domingo-Esmeraldas road, road to Puerto Quito, R. Salazar, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); few exuviae, Santo Domingo-Esmeraldas road, R. Savalito, 24.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); several pupae & larvae, **Cotopaxi Province**, Quevedo-La Maná-Pilaló road, 260m, bridge over San Pablo, riachuelo, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 17 pupae, 20 larvae, **Guayas Province**, Naranjal-Machala road, via Cooperative 11th of August road, 60m, stream, 19.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, 17 pupae, 3 larvae, **Manabi Province**, Santo Domingo-El Carmen road, 2km past El Carmen, Km 40, R. Suma, 7.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH).

Simulium sp. near to *S. incrustatum*

PINNED

Brazil: 3♀♀ (reared), 1♂ (reared), **Federal District**, Ribeirao Piripipau, 26.ix.1975, B.M.1979–580 (*A.J. Shelley*), (BMNH).

SLIDE MATERIAL

Brazil: 1♀ (reared), 2♂♂ (1 reared; 1 dissected from pupa), 2 pupal exuviae, 10 larvae, **Federal District**, Córrego Papuda, on DF 18 before R. São Bartolomeu, 18.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4 man-biting ♀♀, Brasilia, University Farm, 9.x.1975, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4 man-biting ♀♀, 1♀ (reared), 1♂ (pupal exuviae missing), 1 pupa, 1 larva, R. Preto, 12.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 1♀ (reared), 2 larvae, west D.F., DF 3, Córrego Samambaia, 7.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), 5 larvae, DF 3, 1km from R. Samambaia, 7.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), west Brasilia, 2km da Granja do Tamanduá, Córrego, 7.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), BR DF 3, Córrego Tamanduá, 7.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), 1km do Córrego Taquaril, Córrego, 28.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), 11km da DF 5, R. Palma, 21.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), 6 larvae, road to Brasilia, 9km from Planaltina, 28.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 9♀♀ (reared), 6♂♂ (reared), 6 larvae, **Goias State**, Brasilia-Formosa road, bridge, R. Pipiripau, 26.ix.1975 & 31.x.1975, B.M.1979–580 (*A. J. Shelley*), (BMNH); 1♂ (reared), Belém-Brasilia road, Córrego Riboleiro, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), Belém-Brasilia road, Km 11, Córrego, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), Belém-Brasilia road, Km 22, Córrego, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), Belém-Brasilia road, Km 72, Córrego, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), Belém-Brasilia road, Km 149, Córrego, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), Belém-Brasilia road, Km 238, Córrego, 27.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), Brasilia-Campos Belos road, Km 237 from junction with Brasilia-Formosa highway, stream, 22.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), Brasilia-Campos Belos road, Km 138 from junction with Brasilia-Formosa highway, stream, 23.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), Brasilia-Campos Belos road, Km 288 from junction with Brasilia-Formosa highway, stream, 21.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 2♂♂ (reared), estrada Niquelandia-Uruaçu, Km 6, Córrego do Cigano, 3.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), estrada Niquelandia-Dois Irmaos, Km 39, R. das Pedras, 4.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), estrada Niquelandia-Dois Irmaos, Km 59, Córrego, 4.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (1 reared; 1 dissected from pupa), 2♂♂ (1 reared; 1 dissected from pupa), 2 pupal exuviae, 3 larvae, estrada Padre Bernardo-Dois Irmaos, Km 2, Córrego, 2.vi.1976, B.M.1979–580 (*A. Taitson*), (BMNH); 1♀ (reared), 1 larva, estrada Padre Bernardo-Dois Irmaos, Km 44, Córrego Dois Irmaos, 2.vi.1976, B.M.1979–580 (*A. Taitson*), (BMNH); 1♂ (reared), estrada Padre Bernardo-Dois Irmaos, Km 43, Córrego Faz Tudo, 4.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH).

SPIRIT MATERIAL

Brazil: 3♂♂ (reared), **Federal District**, R. Palmeiras, 5.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 4♀♀ (reared), 4♂♂ (reared), near Planaltina, Cachoeira Pipiripau, 27.iii.1976, B.M.1979–580 (*B. Faustino*), (BMNH); 1♀ (reared), 18 larvae, Brasilia-Formosa highway, R. Mestre D'Armas, 5.iv.1976, B.M.1979–580 (*B. Faustino*), (BMNH, IOC); 3♀♀, 4 larvae, Brasilia, University Farm, 9.x.1975, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2 larvae, DF3,

Córrego Samambaia, 7.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4 larvae, Córrego Papuda on DF18, before R. São Bartolomeu, 18.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♂♂ (1 with associated exuviae), 1 pupa, 3 larvae, **Goias State**, Brasilia-Campos Belos road, Km 39 from junction with Brasilia-Formosa highway, stream, 23.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), Brasilia-Campos Belos road, Km 138 from junction with Brasilia-Formosa highway, stream, 23.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1 pupa, Brasilia-Campos Belos road, Km 170 from junction with Brasilia-Formosa highway, stream, 23.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), numerous pupae and larvae, Brasilia-Campos Belos road, Km 237 from junction with Brasilia-Formosa highway, stream, 22.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH, IOC); 1♂ (reared), Brasilia-Campos Belos road, Km 239 from junction with Brasilia-Formosa highway, stream, 22.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3 pupae, Brasilia-Campos Belos road, Km 250 from junction with Brasilia-Formosa highway, stream, 22.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3 pupal exuviae, 3 larvae, Belém-Brasilia road, Km 22, Córrego, 26.v.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 5 larvae, estrada Padre Bernardo-Dois Irmãos, Km 2, Córrego, 2.iv.1976, B.M.1979–580 (*A. Taitson*), (BMNH); 1♂ (reared), estrada Niquelandia-Dois Irmãos, Km 39, R. das Pedras, 4.vi.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1 pupa, 1 pupal exuviae, Mambai, 14.vii.1975, B.M.1979–580 (*A.J. Shelley*), (BMNH); 4♂♂ (reared; 2 without associated pupal exuviae), 13 pupae, 13 pupal exuviae, 10 larvae, Brasilia-Formosa road, bridge, R. Pipiripau, 26.ix.1975, 31.x.1975, 23.iii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH).

Simulium (Psaroniocompsa) limbatum Knab

Type material

Guyana: ♀ HOLOTYPE (No.1664), 5♀♀ PARATYPES (No.1614/5), **Rupununi District**, R. Rupununi, ix.1913 (*K.S. Wise*), (BMNH).

as *S. machadoi* Ramírez Pérez

Venezuela: 2♀♀ (reared; pinned), 3♂♂ (reared; pinned), PARATYPES, **Barinas State**, R.Yuca, no date, B.M.1969–676 (*J. Ramírez Pérez*), (BMNH); 2♀♀ PARATYPES (reared; pinned), **Portuguesa State**, Aparicion, no date (*J. Ramírez Pérez*), (BMNH); 1♀ (reared; pinned), 1♂ (reared; pinned), PARATYPES, Ospino, no date, B.M.1969–676 (*J. Ramírez Pérez*), (BMNH).

Pinned

Brazil: 8 man-biting♀♀, 3♀♀ (reared), 2♂♂ (reared), **Roraima State**, Igarapé do Gelo, 29.xi.1980 (*A.J. Shelley*), (BMNH); 1 man-biting ♀, near Boa Vista, 7km north west of R. Cauamé, 4.iv.1976, B.M.1979–580 (*R.R. Pinger*), (BMNH); 3♂♂ (reared), R. Cauamé, Cachoeira, 21.xi.1980 (*A.J. Shelley*), (BMNH); 1♀ (reared), 2♂♂ (reared), 70km from Boa Vista, Igarapé, 29.xi.1980 (*A.J. Shelley*), (BMNH); 1 man-biting ♀, near Boa Vista, R. Cauamé, 16.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2 man-biting ♀♀, Boa Vista, Igarapé Grande, 30°10'S 60°40'W, 9.v.1978, B.M.1979–580 (*A.J. Shelley*), (BMNH); 28 man-biting♀♀, near Boa Vista, Igarapé Sta. Cecilia, 21.xi.1980 (*A.J. Shelley*), (BMNH); 1♀ (reared), northern perimeter road, R. Agua Preta, 18.xi.1980 (*A.J. Shelley*), (BMNH); 1♀ (reared), Boa Vista-Sta.Helena road, Igarapé Cunaen, 20.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 19♀♀, near Boa Vista, R. Murupu, 19.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀ (reared), 7♂♂ (reared), Boa Vista-Venezuela road, Igarapé Murupu, 19.i.1979 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3 man-biting ♀♀, 40♀♀ (5 reared), 4♂♂ (reared), near Boa Vista, R. Murupú, 25.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*) & 3.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 7♀♀ (reared), 4♂♂ (reared), near Boa Vista, R. Murupú, tributary, 3.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 10 man-biting ♀♀, near Boa Vista, Igarapé Caraná, 16 & 19.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3 man-biting ♀♀, Boa Vista-Caracaraí Road, R. Mucajaí, 17.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting ♀♀, 7♀♀ (reared), 4♂♂ (reared), Km 123 on Boa Vista-Alto Alegre road, R. Au-Au, 19.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH, IOC); 7 man-biting ♀♀, R. Auau, 2.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting♀♀, 11♀♀ (1 reared), near Bonfim, R.Arraia, 3.xii.1980 (*A.J. Shelley*) & 14.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4♀♀ (1 reared), **Amapá State**, Afluente do Tracajatuba, R. Limáo Branco, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH); 1♀, **Matto Grosso State**, R. Torvo, on Xavatina road, 7.iii.1968 (*RS/RGS Expedition*), (BMNH); 10♀♀, **State not recorded**, Tirios, 3.iv.1966 (*R. Lainson*), (BMNH); 1♀, iii.1968 (*B. Freeman*), (BMNH). **Guyana**: 11 man-biting♀♀, 2♂♂ (reared), St. Ignatius Crossing, R. Mocomoco, site no.14, 20.iii.1970, 10.i.1975 (*J.B. Davies*), (BMNH); 2 man-biting ♀♀, 1♀ (reared), bridge on R. Moco-Moca, 11.i.1975 (*J.B. Davies*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), Lethem, 1 mile above St. Ignatus crossing, R. Mocomoco, 27.xi.1970 (*J.B. Davies*), (BMNH); 4♀♀ (reared), Cent. Ranch, R. Kuma, 17.i.1975 (*J.B. Davies*), (BMNH); 1♀ (reared), Francis', R. Kuma, 17.i.1975 (*J.B. Davies*), (BMNH); 14 man-biting ♀♀, 2♂♂ (reared), bridge at R. Kuma (sites 11 & 12), 20.iii.1970, 28.xi.1970 (*J.B. Davies*), (BMNH); 2 man-biting ♀♀, R. Barru crossing (site 13), 20.iii.1970 (*J.B. Davies*), (BMNH); 40 man-biting ♀♀, MEP camp, R. Kumu, 28.xi.1970 (*J.B. Davies*), (BMNH); 2♂♂ (reared), R. Burru, 13.i.1971 (*collector not stated*), (BMNH); 10 man-biting ♀♀, near Lethem, R. Burru (crossing), 3°17'N, 59°49'W, 28.xi.1970 (*J.B. Davies*), (BMNH); 10 man-biting ♀♀, near Lethem, confluence of R. Ireng and R. Tabatinga, 3°23'N, 59°47'W, 27.xi.1970 (*J.B. Davies*), (BMNH); 17 man-biting ♀♀, near Lethem, R. Tabatinga, 3°21'N 59°48'W, 27.xi.1970 (*J.B. Davies*), (BMNH); 5 man-biting ♀♀, near Lethem, Manari Creek, 16.vi.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH).

Slide mounted

Brazil: 9 man-biting ♀♀, 2♀♀ (reared), 1♂ (reared), **Roraima State**, near Boa Vista, R. Murupú, 17 & 19.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), 70km from Boa Vista, Igarapé, 29.xi.1980 (*A.J. Shelley*), (BMNH); 1 man-biting ♀♀, R. Mucajaí, bridge on Boa Vista-Caracaraí road, 17.i.1979 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), R. Cauamé, Cachoeira, 22.xi.1980

(*A.J. Shelley*), (BMNH); 1 larva, road to Embrapa, near R. Cauamé, Igarapé do Carrapato, 10.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting ♀♀, R. Auau, 2.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, near Bonfim, R. Arraia, 14.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); **Mato Grosso State**, 3♀♀ (1 head only; 2 abdomen only), several eggs, no date, (*RS/RGS Expedition*), (BMNH).

SPIRIT MATERIAL

Brazil: 2♀♀ (reared), 1♂ (reared), 2 pupae, 2 larvae, **Roraima State**, Igarapé do Gelo, 29.xi.1980 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), R. Cauamé, Cachoeira, 22.xi.1980 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), 70km from Boa Vista, Igarapé, 29.xi.1980 (*A.J. Shelley*), (BMNH); 2 man-biting ♀♀, near Boa Vista, R. Cauamé, 16.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 30 man-biting ♀♀, numerous exuviae and larvae, near Boa Vista, Igarapé Sta. Cecilia, 22–25.xi.1980 (*A.J. Shelley*), (BMNH, IOC); several man-biting ♀♀, 4♀♀ (reared), 1 exuviae, near Boa Vista, R. Murupú, 17 & 19.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4♂♂, numerous pupae, near Boa Vista, R. Murupú, tributary, 3.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, near Boa Vista, Igarapé Caraná, B.M.1979–580, 19.i.1979 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, bridge of Boa Vista-Caracaraí Road, R. Mucajaí, 17.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous man-biting ♀♀, R. Auau, 2.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 8 man-biting ♀♀, near Bonfim, R. Arraia, 14.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 5 pupae, 3 exuviae, 2 larvae, road to Embrapa, near R. Cauamé, Igarapé do Carrapato, 10.vii.1984, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); numerous ♀♀, **Mato Grosso State**, 70km south of 12.50/51.45, on Xavatina road, R. Torvo, 7.iii.1968 (*RS/RGS Expedition*), (BMNH); several man-biting ♀♀, **State not recorded**, Tirios, 3.iv.1966 (*R. Lainson*), (BMNH).

Guyana: 2♀♀ (1 reared), 1♂ (reared), **Rupununi District**, bridge at R. Kuma, 20.iii.1970, 28.xi.1970 (*J.B. Davies*), (BMNH).

Simulium (Psilopelmia) bipunctatum Malloch

TYPE MATERIAL

Peru: 1♀ HOLOTYPE (pinned) & 1♀ PARATYPE (pinned), R. Charape, 13.ix.1911 (*C.H.T.T. Townsend*), (USNM, BMNH).

as *S. antillarum* Jennings

St Croix Island: 1♂ LECTOTYPE, 1♀ PARALECTOTYPE, several pupae, Frederiksted, 24.xi.1913 (*A. H. Jennings*) (USNM).

PINNED

Brazil: 3 man-biting ♀♀, **Roraima State**, MEVA, mission post, R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 5 man-biting ♀♀, **Amazonas State**, Igarapé Tiquié, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH).

Colombia: 3 man-biting ♀♀, Norte de Santander, Arboledas, Siravita, La Esperanza, 25.xi.1984, 13.vi.1986 (16.00 hrs), 19.vii.1986 (16.00 hrs), (*B. Alexander*), (BMNH).

Dominican Republic: 6♀♀, Roseau, vii–viii.1974 (*L.J. Charles*), (BMNH); 5♀♀, La Vega, near mouth of Arroyo Los Dajaos, 5km east Manabao, 740m, 19°04'N 70°45'W, (riparian woodland), 9.x.1991 (*J. Rawlins, R. Davidson, C. Young & S. Thompson*), (BMNH); 5♀♀, Dajabon, 9km S. Loma de Cabrera, 19°21'N 71°37'W, 620m, (pastures in mesic woodland), 12.vii.1992 (*J. Rawlins, R. Davidson, C. Young & S. Thompson*), (BMNH); 5♀♀, Independencia, 4km south Los Pinos, Loma de Vientos, 18°35'N 71°46'W, 455m, (semiarid deciduous forest with pastures), 23.vii.1992 (*R. Davidson, J. Rawlins, S. Thompson & C. Young*), (BMNH); 5♀♀, El Seibo, Loma Cocuyo, 6km north pedro Sanchez, 18°55'N 69°07'W, 475m, (fields and woodland), 4.vii.1992 (*C. Young, R. Davidson, & S. Thompson*), (BMNH).

Ecuador: 1 man-biting ♀, **Esmeraldas Province**, San Miguel de Cayapa, R. Cayapa, Los Pênas, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, San Miguel de Cayapa, R. Cayapa, 28.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 25♀♀ (reared), 16♂♂ (reared), 2 pupal exuviae, 4km below San Miguel de Cayapa, R. Cayapa, cascadita, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), San Miguel de Cayapa, R. San Miguel, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 1♂ (reared), San Miguel de Cayapa, R. San Miguel, small feeder stream, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), Naranjal (R. Canandé), R. Aguas Negras, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), Naranjal (R. Canandé), esterito, Aguas Claras, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Calle Mansa, forest stream flowing into R. Canandé, 25.ix.1983 (*M. Arzube & A.J. Shelley*), (BMNH); 1♂ (reared), Santo Domingo-Esmeraldas road, 100m, R. Achioti, 26.ix.1983 (*M. Arzube & A.J. Shelley*), (BMNH); 1♂ (reared), R. Grande (Cayapa), Las Pinas, trickle by house, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), **El Oro Province**, Machala-Uzcrume road, Sitio Basaurco, R. Limon, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Machala-Piñas road, before Zaruma, after Santa Rosa, 760m, stream after waterfall, 21.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH).

Jamaica: 3♀♀, 4♂♂, Wag Water, 6.iii.1958 (*D.J. Lewis*), (BMNH); 1♀ (reared), 5♂♂ (reared), 1 pupal exuviae, Clarendon, R. Pindars, near Kellits, 17.vii.1970, B.M.1970–455 (*J. Farradane*), (BMNH).

Montserrat: 3 man-biting ♀♀, (woodlands), 20.ix.1938 (*F.A.S*), (BMNH).

Venezuela: 1♀, **Monagas State**, Quebrada, La Hacienda, 19.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 3♀♀, 1♂, La Pumerosa, 18 & 25.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1 man-biting ♀, 1♀, El Rincon, 2.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀, 24.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH). [Labelled by Lewis as sp. D and regarded by Ramírez Pérez as *S. pseudoantillarum*].

SLIDE MOUNTED

Brazil: 3 man-biting ♀♀, **Amazonas State**, Igarapé Tiquié, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH).

Ecuador: 1 man-biting ♀♀, **Esmeraldas Province**, R. Cayapa, 0°42'N 78°54'W, 28.vi.1980 (*A.J. Shelley & M. Arzube*), (BMNH); 2 man-biting ♀♀, San Miguel de Cayapa,

R. Cayapa, 18–21.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 larva, San Miguel de Cayapa, R. San Miguel, 17.vi.1981 (*A.J. Shelley & M.Arzube*), (BMNH); 4♀♀ (reared), 4♂♂ (reared), 4km below San Miguel de Cayapa, R. Cayapa, cascadita, 17.vi.1981 (*A.J. Shelley & M.Arzube*), (BMNH); 1 man-biting ♀, 1 larva, San Miguel de Cayapa, Estero Hacha, 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 6 larvae, R. Cayapa, stream 1km above Sapallo Grande mission, waterfall in forest, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH).

Jamaica: several pupae, exuviae & larvae, Wag Water, 6.iii.1958 (*D. J. Lewis*), (BMNH); 1 pupa, 1 exuviae, 2 larvae, R. Negro, 8.iii.1958 (*D.J. Lewis*), (BMNH); 3 pupae, several larvae, Salem, 25.ii.1958 (*D.J. Lewis*), (BMNH).

Venezuela: 1 man-biting ♀ (not complete specimen), **Aragua State**, El Loro, x.1969 (*B.O.L. Duke*), (BMNH); 1 man-biting♀ (not complete specimen), **Carabobo State**, Alta Mira, x.1969 (*B.O.L. Duke*), (BMNH); several pupae & exuviae, **Monagas State**, La Pumerosa (el Cupei), 580m, 11 & 24.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1 man-biting ♀ (parts of genitalia & leg), 2♀♀ (parts of genitalia & leg), El Rincón, 2.v.1961, iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♂ (parts of genitalia only), few exuviae, Quebrada, La Hacienda el Mango, 19.v.1961 (*D.J. Lewis*), (BMNH); 1♂ pupa, 1 exuviae, Guatopo, 28.vi.1961 (*D.J. Lewis*), (BMNH); 1♂ pupa, 1 exuviae, El Piñon el Calicha, 11.v.1961 (*D.J. Lewis*), (BMNH); few pupae, R. Macho, 520m, 15.v.1961 (*D.J. Lewis*), (BMNH).

SPIRIT MATERIAL

Brazil: 19 man-biting ♀♀, **Amazonas State**, Igarapé Tiquié, tributary of R. Vaupes, 15.xii.1977 (*C. Vicente*), (BMNH).

Ecuador: 1♀, **Esmeraldas Province**, R. Cayapa, 0°42'N 78°54'W, 28.vi.1980 (*M. Arzube*), (BMNH); 6 man-biting♀♀, San Miguel de Cayapa, R. Cayapa, 26–28.v.1981, 18–21.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); several pupal exuviae & larvae, San Miguel de Cayapa, R. San Miguel, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 4 man-biting♀♀, San Miguel de Cayapa, R. Cayapa, Las Penãs, 27 & 28. v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 3 pupae, 2 pupal exuviae, 2 larvae, R. Cayapa, 3km above San Miguel, cascade in small town, 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀ (reared), 5♂♂ (reared), 4 pupae, 2 pupal exuviae, 4km below San Miguel de Cayapa, R. Cayapa, cascadita, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 3♂♂ (reared), 6km below San Miguel de Cayapa, R. Cayapa, forest stream, 28.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂, 6 exuviae, R. Cayapa, Agua Blanca, 22.xi.1984 (14.50 hrs) (*M.L. Kuns*), (BMNH); 1 pupa, 1 larva, Viruela, R. Cayapa, (1hr above San Miguel by motorized canoe), 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 3 man-biting ♀♀, 1♂ (reared), numerous pupae, exuviae & larvae, San Miguel de Cayapa, Estero Hacha, 26.v.1981, (*A.J. Shelley & M. Arzube*), (BMNH); numerous pupae, exuviae & larvae, R. Cayapa, stream 1km above Sapallo Grande mission, waterfall in forest, 17.vi.1981, 28.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2 pupal exuviae, 1 larva, between San Miguel & Sapallo Grande mission, small forest stream flowing into R. Cayapa, 22.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2 pupae, 1 pupal exuviae, 4km above Sapallo Grande mission, R. Sapallo Grande, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting ♀, Tumbaviro, R. Sapallo Grande, 24.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 pupal exuviae, 1 larva, 0.5km below Tumbaviro, R. Sapallo Grande, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 man-biting♀, Naranjal (R. Canandé), R. Canandé, 1.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 1larva, Naranjal (R. Canandé), R. Naranjal, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 7 larvae, Naranjal (R. Canandé), R. Aguas Negras, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 5♀♀, **Galapogos Islands**, Cristobal, v.1991 (*J. Satomayor*), (BMNH).

Venezuela: 7 pupae, 2 pupal exuviae, **Monagas State**, Caripe area, La Pumerosa, 580m, 18.v.1961 (*D.J. Lewis*), (BMNH).

Simulium dinellii Joan

PINNED

Brazil: 1♀, **Pará State**, Nova Teutonia, 09°11'S 52°23'W , 28.x.1936, B.M.1937–265 (*F. Plaumann*), (BMNH).

Argentina: 24♀♀, Jujuy, no date, B.M.1949–76 (*W. C. Paterson*) (BMNH).

Bolivia: 1♀, Villa Montes, v.1926, B.M.1933–168 (*Lind. D. Chaco Exped.*), (BMNH).

Peru: 18♀♀, Apurimac, Cuzco-Abancay road, Apurimac crossing at Cuya, 1900m, 7.viii.1971, B.M.1971–533 (*C. & M. Vardy*) (BMNH); 2 man-biting ♀♀, Coloradito, 30.v.1989 (*K. Wallbanks*), (BMNH).

SLIDE MOUNTED

Bolivia: 2 man-biting ♀♀, Chichipa, Los Yungas, outside Hacienda, 25.v.1986 (*R. Ward*), (BMNH).

Peru: 1♀, Apurimac, Cuzco-Abancay road, Apurimac crossing at Cuya, 1900m, 7.viii.1971, B.M.1971–533 (*C. & M. Vardy*) (BMNH); 1 man-biting ♀, Coloradito, 30.v.1989 (*K. Wallbanks*), (BMNH).

SPIRIT MATERIAL

Bolivia: 7 man-biting ♀♀, Chichipa, Los Yungas, outside Hacienda, 25.v.1986 (*R. Ward*), (BMNH).

Honduras: 1 larvae, **Dept. de Cortes**, stream El Cacao, 250m from treatment point, 23.iii.1984 (*Lacey*), (BMNH).

Simulium ochraceum Walker

PINNED

Guatemala: 3♀♀, **Department Chimaltenango**, Finca Sta. Anita, 8.iii.1974 (*R. Garms*), (BMNH); 1♀, 2♂♂, Acatenango, 2.x.1948, 8.vi.1949 (*H. Dalmat*), (BMNH); 1♀ (No.1025–2), 1♂ (No.1025–8), no date, B.M.1962–675 (*H. Dalmat*), (BMNH).

Mexico: 3♀♀, Chalchihuitan, 4.xii.1940, B.M.1949–236 (*J. Parra*) (BMNH); 10♀♀, **Chiapas State**, Huixtla, x.1958 (*R. W. Crosskey*), (BMNH); 6 man-biting ♀♀, Acacoyagua, Golondrinas, 22.i.1987 (*A.L. Millest*), (BMNH); 30 man-biting♀♀, Huixtla, Morelos, 29 & 30.vi.1985, 25.i.1987 (*A.L. Millest*), (BMNH); 6 man-biting ♀♀, Escuintla, Xalapa, 24.i.1987 (*A.L. Millest*), (BMNH); 15 man-biting ♀♀, Tapachula, Chespal, 18.vii.1985, 10.ii.1987 (*A.L. Millest*), (BMNH); 1♀, El Bosque, LosAngeles, 6.xi.1987 (*A.L. Millest*), (BMNH); 1♂ (reared), Tuzantan, San Cristobal, 22.vii.1985

(*A.L. Millest*), (BMNH); 1♀ (reared), **Oaxaca State**, S. Juan Yaée, Yaée, 24.x.1987 (*A.L. Millest*), (BMNH).

Panama: 1♀, **Chiriqui Province**, Los Planes de Hornito, 12.ix.1978 (*J. Petersen*) (BMNH).

SLIDE MOUNTED

Costa Rica: 1 larva, **Heredia Province**, La Selva, Quebrado Esquina, at 1700m trail marker on Sendero-Sábalo-Esquina, 12.vi.1986 (*R.W. Lichtwardt*), (BMNH).

Guatemala: 2♀♀, **Department Chimaltenango**, Finca St. Emilia, 21.iii.1974 (*R. Garms*), (BMNH); 1♀ cibarium, Finca St. Anita, 6.iii.1974 (*R. Garms*), (BMNH); 3 man-biting ♀♀, Yepocapa Area, 1965 (*B.O.L. Duke*), (BMNH).

Mexico: 5 man-biting♀♀, **Chiapas State**, Huixtla, no date (*collector not stated*), (BMNH); 3 man-biting ♀♀, Morelos, near Huixtla, 22.xi.1979 (*C. Mackenzie*), (BMNH); 1 pupa, Zajú, Guadalupe, iii.1946 (*A. Diaz Najera*), (BMNH); 1 larva, Union Fronteriza, v.1952 (*A. Alvarado*), (BMNH).

SPIRIT MATERIAL

Costa Rica: 1 pupa, 4 exuviae, 5 larvae, **Guanacaste Province**, very small stream along Sendero Nubosa, near marker #9 in Manteverde Reserve, 16.x.1984 (*R.W. Lichtwardt*), (BMNH); 6 larva, **Heredia Province**, La Selva, Quebrado Esquina, at 1700m trail marker on Sendero-Sábalo-Esquina, 12.vi.1986 (*R.W. Lichtwardt*), (BMNH); 2 larvae, La Selva, Quebrado el Salto, 19.x.1984, 26.ix.1989 (*R.W. Lichtwardt*), (BMNH).

Guatemala: 5♀♀, **Department Chimaltenango**, Finca St. Emilia, 21.iii.1974 (*R. Garms*), (BMNH); numerous ♀♀, Yepocapa Area, 1965 (*B.O.L. Duke*), (BMNH); numerous♀♀, Yepocapa Area, no date (*collector not stated*), (BMNH).

Mexico: numerous ♀♀, **Chiapas State**, Huixtla, no date, (*collector not stated*); 15♀♀, Morelos, near Huixtla, 22.xi.1979 (*C. Mackenzie*), (BMNH); numerous ♀♀, Morelos, Colonia, 1954, (*V. Marraquin*), (BMNH); 4♀♀ (reared), 1♂ (reared), 3 exuviae, Zajú, Guadalupe, iii.1946 (*A. Diaz*), (BMNH); 1 pupa, several larvae, Union Fronteriza, v.1952 (*A. Aluarado*), (BMNH).

Panama: 3♂♂ (reared), **Chiriqui Province**, Los Planes de Hornito, 19km north east of Gualaca, 8°38'N 82°14'W, 18.i.1978, 12.ix.1978 (*J. Petersen*), (BMNH).

Simulium (Psilopelmia) iracouboense Floch & Abonnenc

TYPE MATERIAL

French Guiana: 1♀ (reared) LECTOTYPE (slide no.755), 1♂ (reared) PARALECTOTYPE (slide no.756), Cafèsoca, 5.vi.1946 (*collector not stated*), (1P).

PINNED

Brazil: 3♀♀ (reared), 2♂♂ (reared), **Roraima State**, mission post, R. Catrimani, 9.i.1977, B.M.1979–580 (*A.J. Shelley*) & 13.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4♀♀ (reared), 1♂ (reared), mission post, R. Mucajaí, 5 & 6.i.1977 (*A.J. Shelley*), (BMNH); 1♀ (reared), 3♂♂ (mass reared), R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, Mt. Aripuanã, above waterfall, 12.xi.1978 (*L.A. Lacey*), (BMNH); 7♀♀ (reared; 3 pupal exuviae missing), 6♂♂ (reared; 1 pupal exuviae missing), **Amapá State**, above Maripa Falls, R. Oyapock, 21.v.1992 (*C. Lowry &A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), R. Patanarí, (tributary of R. Oyapock), rapids, 22.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH).

SLIDE MOUNTED

Brazil: 1♀ (reared), 2♂♂ (reared), 1 larva, **Roraima State**, Catrimani mission, R. Catrimani, 9.i.1977, 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀♀ (reared), 1♂ (genitalia only), 1 pupa, 2 larvae, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 1♂ (reared), R. Mucajaí, 5.i.1977 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), Igarapé down river from Coroconaí (Mucajaí), 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀(reared), 1♂ (reared), **Amapá State**, R. Patanarí, (tributary of R. Oyapock), rapids, 22.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH).

SPIRIT MATERIAL

Brazil: 4♀♀ (reared), 2♂♂ (reared), several pupae and exuviae, 3 larvae, **Roraima State**, mission post, R. Catrimani, 9.i.1977, B.M.1979–580 (*A.J. Shelley*) & 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), several pupae, 28 larvae, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), several pupae, several larvae, R. Mucajaí, Coroconaí, Igarapé downriver, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 6♀♀ (reared; 3 without associated pupal exuviae), 13♂♂ (reared; 5 without associated pupal exuviae), 12 pupae, 17 larvae, R. Mucajaí, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 6 pupae, 3 pupal exuviae, R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4♀♀ (reared), 2♂♂ (reared), several pupae, 19 larvae, **Amapá State**, above Maripa Falls, R. Oyapock, 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 5♀♀ (reared), 6♂♂ (reared), several pupae, R. Patanarí, (tributary of R. Oyapock), rapids, 22.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH).

Surinam: several pupae, several larvae, Apoma Tapoe, Marowigne River, 4°49'N 54°26'W, 19.xi.1979 (*J.E. Hudson*), (BMNH); few pupae, several larvae, Soekibakka, Saramacca River, 4°20'N 55°45'W, 7.iv.1981 (*J.E. Hudson*), (BMNH); 4 pupae, several larvae, Sajé, Tapanahony River, 4°13'N 54°32'W, 18.i.1979 (*J.E. Hudson*), (BMNH).

Simulium (Psilopelmia) samboni Jennings

PINNED

Mexico: 1♀, Chiapas, Hannover, 12.viii.1942, B.M.1949–236 (*A. Diaz*), (BMNH); 1♀, Chiapas, El Rosario, 18.viii.1942, B.M.1949–236 (*A. Diaz*), (BMNH); 1♀, 1♂, Veracruz, Canaleta, xii.1948 (*F. Reyes*), (BMNH).

Panama: 6♀♀ (reared; 1 pupal exuviae missing), 16♂♂ (reared), 2 pupal exuviae (associated ♀ & ♂ on slide), **Canal Zone**, Junction of roads K6 and K9, R. Cocoli, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), between

Empire Range and Canal, on K2, R. Comacho, 1–6.vii.1985 (*A.J. Shelley*), (BMNH).

Venezuela: 1♀ (reared), **Barinas State**, 80km de Barinas, R. Socopo, no date, B.M.1969–676, (*J. Ramírez*, (BMNH); 1 man-biting♀, **Cojedes State**, Altamira, 16.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀, **Guarico State**, San Juan d'Morros, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 6♀, 5♂♂, Altagracia, Quebrada Caramacare, 28.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀ (reared), 1♂ (reared), **Miranda State**, Guarenas, Carupao, (no date), B.M.1969–676 (*J. Ramírez*), (BMNH); 1♂ (reared), **Monagas State**, San Antonio, no date (*J. Ramírez*), (BMNH); 5♀♀, 13♂♂, Guanaguana, 5.iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 4♀♀ (reared), 2♂♂ (reared), R. Colorado, 6.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀, 2♂♂, R. Guatatal, 15.iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 3♀ (reared), 4♂♂ (reared), El Salto, 26.iv.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀ (reared), **Portuguesa State**, Agua Blanca, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 2♀♀ (reared), 1♂ (reared), San Rafael, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♂, **State not recorded**, R. Hembra, 10.v.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♂, Tucyito, Quebrada Marbellaco, 14.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH).

SLIDE MOUNTED

Costa Rica: 1 larva, La Selva, Quebrada El Salto above waterfall, 1.vi.1988 (*R.W. Lichtwardt*), (BMNH).

Honduras: 1♂, **Dept. de Cortes**, small stream El Cacao, 250m from treatment point, (24 hrs post treatment), 24.iii.1984 (*L.Lacey*), (BMNH).

Panama: 4♀♀ (1 dissected from pupa; 3 reared, 1 pupal exuviae in pinned collection), 2♂♂ (reared, 1 pupal exuviae in pinned collection), **Canal Zone**, junction of roads K6 and K9, R. Cocoli, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 2 larvae, between Empire Range and canal, on K2, R. Comacho, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 1 larva, **Coclé Province**, El Valle, R. Antón, 680m, La Mapolo, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 1 larva (ex cytology), El Valle, ½km above bridge at San Carlos, 1–6.vii.1985 (*A.J. Shelley*), (BMNH).

Venezuela: 2♂♂, 15 pupal exuviae, Quebrada Caramacare, 28.vi.1961 (*D.J. Lewis*), (BMNH); 2♀♀ (genitalia), 1♂ (genitalia), 16 pupal exuviae, Guanaguana, 5.iv.1961, B.M1962–380 (*D.J. Lewis*), (BMNH); 1 man-biting ♀, Altamira, 15.vi.1961 (*D.J. Lewis*), (BMNH); 3 pupal exuviae, R. Guatatal, 5.iv.1961 (*D.J. Lewis*), (BMNH); 1 pupal exuviae, Quebrada Marbellaco, 14.vi.1961 (*D.J. Lewis*), (BMNH); 6 pupae (some exuviae only), Tucuaguanal, 30.v.1961 (*D.J. Lewis*), (BMNH).

SPIRIT MATERIAL

Honduras: 1♀, 1♂, 7 pupae, 1 larva, **Dept. de Cortes**, small stream El Cacao, 250m from treatment point, 24.iii.1984 (*L.Lacey*), (BMNH); 1 pupa, 2 larvae, small stream El Cacao, 1.5km from treatment point, 23.iii.1984 (*L.Lacey*), (BMNH).

Panama: 2♀♀ (reared), 3♂♂ (reared), numerous pupae, several larvae, **Canal Zone**, junction of roads K6 and K9, R. Cocoli, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 1 pupa, several exuviae, several larvae, between Empire Range and canal, on K2, R. Comacho, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 3♂♂ (reared), 5 pupae, 2 pupal exuviae, 4 larvae, near Gatuncillo, R. Limon, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 1♂ (reared), 5 pupae, 3 pupal exuviae, 2 larvae, Summit gardens, stream in gardens, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1 larva, **Coclé Province**, El Valle, R. Antón, 680m, La Mapolo, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 2 pupal exuviae, 3 larvae, El Valle, R. Antón, 560m, La Reforma (pasture), 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), several pupae, several larvae, El Valle, R. Antón, 560m, 1–6.vii.1985 (*A.J. Shelley*), (BMNH); 2 pupae, 8 larvae, **Panama Province**, near town of Torti, R. Torti, 8°53 N 78°27'W, 19.i.1985 (*J. Peterson & J.E. Conn*), (BMNH).

Simulium (Psilopelmia) lutzianum Pinto

TYPE MATERIAL

as *S. lewisi* Ramírez Pérez

Venezuela: 1♂ PARATYPE (reared), **Barinas State**, 80km de Parinas, R. Socopo, no date (*J. Ramírez*), (BMNH); 1♀ PARATYPE (reared), **Carabobo State**, Virigima, no date (*J. Ramírez*), (BMNH); 1♀ PARATYPE (reared), **Miranda State**, Panaquire, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀ PARATYPE (reared), Acevedo District, Panaquire, 70m, R. Yaguapo, no date (*J. Ramírez*), (BMNH).

PINNED

Ecuador: 4♀♀ (reared), 4♂♂ (reared), **Esmeraldas Province**, Naranjal (R. Canandé), R. Naranjal, 23.vi.1985, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 12♀♀ (reared), 7♂♂ (reared), Naranjal (R. Canandé), R. Aguas Negras, 25.ix.1983, 23.vi.1985, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀ (reared), 2♂♂ (reared), San Miguel de Cayapa, R. San Miguel, 26.v.1981, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), San Miguel de Cayapa, R. San Miguel, small forest stream, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), San Miguel de Cayapa, 4km below, R. Cayapa, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 2♂♂ (reared), Tumbaviro, R. Sapallo Grande, 18.vi.1981, 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀ (3 reared), 4♂♂ (reared), Santo Domingo-Esmeraldas road, near Concordia, road to Puerto Quito, R. Caoni, 23 & 24.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 1♂ (reared), Santo Domingo-Esmeraldas road, near Concordia, road to Puerto Quito, R. Salazar, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), Tululbi (Ricaurte), R. Bogota, 13.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 1♂ (reared), 4km from San Lourenço, on Tululbi road, R. Nadadeira, 14.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), **Chimborazo Province**, Bucay-Pallatanga road, R. Opalito, 11.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 1♂ (reared), **El Oro Province**, Machala-Uzcrume road, 220m, un-named Rio, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), **Guayas Province**, Naranjal-Machala road, via Co-operative 11th August road, 80m, forest stream, 19.vi.1984 (*A.J. Shelley & M.Arzube*), (BMNH); 1♀ (reared), **Imbabura Province**, Salinas-Lita road, 54km from Ibarra, R. San Pedro, 11.ix.1983 (*A.J. Shelley & M.Arzube*), (BMNH); 1♀ (reared), 2♂♂ (reared), **Los Ríos Province**, Babahoyo-Montalvo road,

800m, R. Cristal, Madeira bridge, 10.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), **Manabi Province**, Chone-Santo Domingo de Los Colorados road, R. Maiceto, stream/river, 10.xii.1984 (*A.J. Shelley & M.Arzube*), (BMNH); 1♀, 2♂♂ (reared), **Napo Province**, near Lago Agrio, Shushufindi-Lago Agrio road, 20km from Shushufindi, 14.xii.1982 (*A.J. Shelley & M.Arzube*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), **Cotopaxi Province**, Quevedo-La Mana-La Pilalo road, near La Mana, 260m, Recinto Beles, R. San Pablo bridge, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), Quevedo-La Mana-La Pilalo road, 50km from Quevedo, 620m, R. California, 9.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 15♀♀ (reared), 8♂♂ (reared), **Pastaza Province**, Tena-Puyo road, near Manantial, 920m, R. Huamayacu, 9 & 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 3♂♂ (reared), Tena-Puyo road, 880m, R. Pinto Chico, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 3♀♀ (reared), 1♂ (reared), Tena-Puyo road, 4.5km from Puyo, 820m, R. Puyo, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 4♀♀ (reared), 3♂♂ (reared), Tena-Puyo road, via Puerto Napo, 460m, R. Mira Valle, 8.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), Tena-Puyo road, via Puerto Napo, 1km from confluence with R. Tena, R. Upano, 1km from confluence of R. Tena, 8.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), Tena-Puyo road, via Puerto Napo, R. Santa Rosa, 8.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 11♀♀ (reared), 5♂♂ (reared), **Pichincha Province**, Quito-Santo Domingo road, 600m, R. Tanti, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), 1♂ (reared), Quito-Santo Domingo road, 640m, R. Lelia, 29.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), **Tungurahua Province**, Shell Mera-Baños road, 1340m, stream, 11.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), **Zamra-Chinchipe Province**, Loja-Zamora road, Sabanilla, 1680m, multiple streams, 25.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH).

Venezuela: 2♀♀ (reared), 1♂ (reared), **Aragua State**, Rancho Grande, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀, Tucuyito, R. Aguacatal, 14.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 2♀♀, 1♂, Altagracia, Quebrada Caranacare, 28.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 1♀ (reared), 1♂ (reared), **Carabobo State**, Montalban, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀ (reared), **Merida State**, Timotes, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 3♂♂ (reared), 1650m, Merida, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀ (reared), **Miranda State**, Acevedo District, 80m, El Clavo, R. Sapo, no date (*J. Ramírez*), (BMNH); 2♀♀ (reared), 3♂♂ (reared), 350m, El Ingenio, Guatire, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀ (reared), 2♂♂ (reared), Departamento Plaza, 550m, R. Izcaragua, no date, B.M.1969–676 (*J. Ramírez*), (BMNH); 1♀ (reared), 1♂ (reared), Carupao, Guarenas, no date, B.M.1969–676 (*J. Ramírez*), (BMNH).

Slide material

Brazil: 1♀ (reared), **Roraima State**, mission post, R. Auaris, 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 1♀ (reared), 3 larvae, **Esmeraldas Province**, Naranjal (R. Canandé), R. Naranjal, 25.ix.1983, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1 larva, Naranjal (R. Canandé), R. Aguas Negras, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), San Miguel de Cayapa, R. San Miguel, 25 & 26.v.1981, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), 1 larva, Tumbaviro, R. Sapallo Grande, 25 & 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 larva, Santo Domingo-Esmeraldas road, near Concordia, road to Puerto Quito, R. Caoni, 23.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), **Cotopaxi Province**, Quevedo-La Mana-Pilaló road, 260m, bridge of R. San Pablo, 8.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), **Pastaza Province**, Tena-Puyo road, 920m, R. Huamayacu, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 3♀♀ (reared), 1♂ (reared), **Pichincha Province**, Quito-Santo Domingo road, 600m, R. Tanti, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH).

Venezuela: 2 donkey biting ♀♀, **Monagas State**, El Quebracho (near Caripe), 7.v.1961 (*D.J. Lewis*), (BMNH).

Spirit material

Brazil: 1♂ (reared), **Goias State**, near Minaçu, Fazenda Margem Esquerda, R. Umburara, 13.x.1991 (*A.J. Shelley*), (BMNH); 1♂ (reared), 2 pupae, 2 exuviae, **Santa Catarina State**, state boundary on BR101, R. São João, 18.xi.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

Ecuador: 2♂♂ (reared), 5 pupae, 2 exuviae, **Esmeraldas Province**, San Miguel de Cayapa, R. San Miguel, 25 & 26.v.1981, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (1 reared), 2♂♂ (1 reared but without associated pupal exuviae), 1 pupa, few exuviae, Agua Blanca, R. Cayapa, 15.vii.1986 (*P. Beech*) & 24.xi.1984 (14.50 hrs), 28.xi.1984 (15.28 hrs) (*M.L. Kuns*), (BMNH); 5 pupae, 2 exuviae, 6 larvae, Calle Mansa, R. Cayapa (1 hr above San Miguel by motorized canoe), 27.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂ (reared), Calle Mansa, R. Grande (Cayapa), 1981 (*A.J. Shelley & M. Arzube*), (BMNH); 3 pupae, R. Cayapa, waterfall in forest stream, 1km above Sapallo Grande mission, 17.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 pupa, R. Cayapa, cascade in small stream, 3km above San Miguel, 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 5 pupae, 1 exuviae, 4km above Sapallo Grande mission, R. Sapallo Grande, 26.v.1981, 18.vi.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 1♂ (reared), 18 larvae, Tumbaviro, R. Sapallo Grande, 25 & 26.v.1981 (*A.J. Shelley & M. Arzube*), (BMNH); 1 pupa, 1 exuviae, Viruela, R. Cayapa (1 hr above San Miguel by motorized canoe), 26.v.1981 (*A.J. Shelley & M.Arzube*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), several pupae & exuviae, numerous larvae, Naranjal (R. Canandé), R. Naranjal, 25.xi.1983, 23.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 3♂♂ (2 reared; 1 without associated pupal exuviae), 4 pupae, 1 exuviae, 10 larvae, Naranjal (R. Canandé), R. Canandé, 25.ix.1983, 24.vi.1985 (*A.J. Shelley & M.Arzube*), (BMNH); 4♀♀ (reared), 6♂♂ (reared), 3 exuviae, Naranjal (R. Canandé), R. Aguas Negras, 25.ix.1983, 23.vi.1985, 3.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (mass reared), 3♂♂ (3 reared; 1 without associated pupal exuviae), 18 pupae, 9 exuviae, 15 larvae, Santo Domingo-Esmeraldas road, near Concordia, road to Puerto Quito, R. Caoni, 23 & 24.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2 pupae, Santo

Domingo-Esmeraldas road, road to Puerto Quito, R. Blanco, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♂, 1 pupa, 2 exuviae, Santo Domingo-Esmeraldas, R. Savalito, 24.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀, R. Chambagal, 28.xi.1984 (15.28 hrs) (*M.L. Kuns*), (BMNH); 1♀, 13 pupae, 3 exuviae, 8 larvae, R. Zapallo, Corredeira Penã, 24.xi.1984 (14.45 hrs) (*M.L. Kuns*), (BMNH); 6 larvae, R. Zapallito, stream at Juan Montaldo, 15.xii.1986 (*P. Beech-Garwood*), (BMNH); 1♀ (reared), Tululbi (Ricaurte), R. Bogota, 13.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), 2 pupae, 4km from San Lourenço, on Tululbi road, R. Nadadeira, 14.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 1 pupa, 7 exuviae, 12.5km from San Lourenço, on Tululbi road, R. Quebrada Chica, 14.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 2♀♀ (reared), **El Oro Province**, Machala-Uzcrume road, 220m, un-named Rio, 20.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), **Guayas Province**, Naranjal-Machala road, via Cooperative 11th August road, 500m from R. Bucay, 80m, forest stream, 19.vi.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 11 larvae, **Manabi Province**, Chone-Santo Domingo de Los Colorados road, R. Maiceto, 11.xii.1984 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 4♂♂ (reared), several pupae & exuviae, 18 larvae, **Napo Province**, near Lago Agrio, Shushufindi Lago Agrio road, 20km from Shushufindi, forest stream, 14.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 11 pupae, 3 exuviae, 12 larvae, near Lago Agrio, Shushufindi-Lago Agrio road, 15km from Shushufindi, forest stream, 14.xii.1982 (*A.J. Shelley & M. Arzube*), (BMNH); 2♂♂ (reared), 1 pupa, 7 larvae, near Lago Agrio, R. Duvino, 23.v.1988, 21.vi.1988 (*A.J. Shelley & M. Arzube*), (BMNH); 5♀♀ (reared), 8♂♂ (2 reared), 2 exuviae, **Pastaza Province**, Tena-Puyo road, 920m, R. Huamayacu, 9 & 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 3♂♂ (3 reared; 2 without associated pupal exuviae), 1 pupa, 1 exuviae, Tena-Puyo road, tributary of riachuelo Huamayacu, 10.vi.1985 (*A.J. Shelley & M.Arzube*), (BMNH); few larvae, Tena-Puyo road, tributary of riachuelo Huamayacu, near manantial, near R. Puyo, 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (mass reared), 2♂♂ (mass reared), few pupae & exuviae, 1 larva, Tena-Puyo road, 880m, R. Pinto Chico, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1 exuviae, 9 larvae, Tena-Puyo road, R. Pinto Chico, Puyo-Ambato, 10.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 6♂♂ (reared; 2 without associated pupal exuviae), 1 pupa, 1 exuviae, 14 larvae, Tena-Puyo road, 4.5km from Puyo, 820m, R. Puyo, 9 & 10.vi.1985 (*A.J. Shelley & M.Arzube*), (BMNH); 7♀♀ (reared; 5 without associated pupal exuviae), 5♂♂ (reared; 3 without associated pupal exuviae), 11 pupae, 6 exuviae, 2 larvae, Tena-Puyo road, Puerto Napo-Puyo, 460m, R. Mira Valle, 8.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 10 larvae, Tena-Puyo road, opposite Tena population, R. Upano, 1km from confluence of R. Tena, 9.vi.1985 (*A.J. Shelley & M. Arzube*), (BMNH); 1♀ (reared), 2 pupae, 2 exuviae, several larvae, **Pichincha Province**, Quito-Santo Domingo road, 600m, R. Tanti, 28.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH); 4 pupae, 640m, R. Lelia, 29.ix.1983 (*A.J. Shelley & M. Arzube*), (BMNH);

Panama: 5 larvae, **Panama Province**, R. Indio, 3km past Calzada, Larga airport, 9°13'N 79°32'W, 23.i.1985 (*J. Peterson & J.E. Conn*), (BMNH).

Venezuela: 8 exuviae, **Carabobo State**, near Valencia, Tukuyito area, R. Aguacatal, 14.vi.1961, B.M.1962–380 (*D.J. Lewis*), (BMNH); 2 exuviae, 5 larvae, [originally as Lewis species A], **Cojedes State**, Altamira area, near Altagracia, Quebrada Garamacare, 28.vi.1961 (*D.J. Lewis*), (BMNH); 3 man & donkey biting♀♀, **Monagas State**, El Quebracho (near Caripe), 7.v.1961 (*D.J. Lewis*), (BMNH).

Simulium (Psilopelmia) rorotaense Floch and Abonnenc

Type material

French Guiana: 1♀ (reared) LECTOTYPE (slide no.751), 1♂ PARALECTOTYPE (slide no.752), Rorota, 31.v.1946 (*collector not stated*), (IP).

as *S. maroniense* Floch and Abonnenc

French Guiana: 1♀ LECTOTYPE (slide no.709), 1♂ PARALECTOTYPE (slide no.708), Coeur Maroni, 12.viii.1945 (*collector not stated*), (IP).

Pinned

Brazil: 1♀ (reared), 1♂ (reared), **Roraima State**, mission post, R. Auaris, 31.iii.1977, B.M.1979–580 (*R.R. Pinger*), (BMNH); 1♀ (reared; pupal exuviae on slide), mission post, R. Mucajaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley & A. P. A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared; fore leg claw mounted), R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), near mission post, R. Mucajaí, Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), R. Preto, tributary of R. Ajaraní, 28–29.iv.1979, B.M.1979–258 (*R.W. Crosskey & A.J. Shelley*), (BMNH); 2♀♀ (reared), 1♂ (reared), Cachoeira, R. Cauamé, 29.iv.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♀ (reared; fore leg claw mounted), Boa Vista-Sta. Helena road, Igarapé Avila, 29.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), **Amazonas State**, Km 26 Estr. Manaus, Ducke Reserve, Igarapé Acará, 20.i.1976 (*Faustino*), (BMNH); 2 man-biting ♀♀, **Mato Grosso State**, Dardanelos Falls, R. Aripuanã, 10°11'S 59°48'W, 22.iii.1977 (*collector not stated*), (BMNH).

Slide mounted

Brazil: 1 pupa (adult pinned), **Roraima Territoy**, mission post, R. Mucajaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (1 reared; 1 partly dissected from pupa), 1♂ (reared), 3 larvae, near mission post, R.Mucaijai, Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 1 pupa, mission post, R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 2♂♂ (reared), Surucucus, Cachoeira 2km from FUNAI Post, 7.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH, IOC); 1♀ (reared), 2♂♂ (reared), Surucucus, Igarapé Falemu (above hydroelectric dam), 10.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting♀, **Pará State**, Carajas District, vi.1983, (*L. Ryan*), (BMNH).

Guyana (as British Guiana): 1♂ (genitalia and single hind legonly) (originally identified as *S. rubrithorax*), Kaieteur, savannah, 4 ix.1937, B.M.1937–778 (*J. Smart*), (BMNH); 3♂♂ (dissected from pupae) (originally identified as *S.*

rubrithorax), High forest, Sandstone bed of stream, Kaieteur/ Takeit Trail, 9.ix.1937, B.M.1937–778 (*J. Smart*), (BMNH).

SLIDE MATERIAL

Brazil: 2♀♀ (reared), 7♂♂ (reared), 3 pupa, **Roraima State**, Surucucus, waterfall 2km from FUNAI post, 7.v.1982 (*A.P.A Luna Dias & R. Malaguti*), (BMNH); 1♀ (reared), Surucucus, Dalem (in river), 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (reared), 2♂♂ (reared), Surucucus, Igarapé Falemu (above hydroelectric dam), 10.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 8 pupae, numerous larvae, near mission post, R. Mucajaí, Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 pupa, Mucajaí mission, Igarapé Coroconaí, 6.i.1977 (*A.J. Shelley*), (BMNH); 1♂ (reared), 9 pupae, 18 larvae, Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂, 3 pupae, 6 pupal exuviae, Boa Vista-Sta. Helena road, Boca da Mato, Igarapé Cunaen, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (mass reared), 1 pupa, Boa Vista-Sta. Helena road, Boca da Mato, Igarapé Cunaen, small stream, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 pupa, Auaris mission post, Igarapé, 9.vii.1979, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), 1 pupal exuviae, 3 larvae, mission post, R. Auaris, 7.vii.1976, B.M.1979–580 (*A.J. Shelley*) & 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, **Pará State**, Carajas District, vi.1983 (*L. Ryan*), (BMNH).

S. wuayaraka Ortiz

Venezuela: 1♂ (reared), **Amazonas Territory**, Parima, 18.iv.1980 (*collector not stated*), (BMNH).

S. *ignacioi* Ramírez Pérez & Vulcano

Venezuela: 1♂ (reared), **Bolivar State**, Wonaven, no date (*collector not stated*), (BMNH).

Simulium (Psilopelmia) suarezi Ramírez Pérez, Rassi and Ramírez

PINNED

Venezuela: 1♂ (reared), **Amazonas Territory**, Mayobuteri, 20.iv.1980, no date (*collector not stated*), (BMNH).

SLIDE MATERIAL

Brazil: 1♂♂ (reared), **Roraima State**, Surucucus, waterfall 2km from FUNAI post, 7 v.1982 (*A.P.A Luna Dias & R. Malaguti*), (BMNH).

SPIRIT MATERIAL

Brazil: 2♂♂ (reared), **Roraima State**, Surucucus, waterfall 2km from FUNAI post, 7 v.1982 (*A.P.A Luna Dias & R. Malaguti*), (BMNH).

Simulium (Trichodagmia) guianense Wise

TYPE MATERIAL

Guyana: 1♀ LECTOTYPE (pinned, head, abdomen, mid and hind legs on slide), 3♀♀ PARALECTOTYPES (pinned, abdomen, wing and hind leg on slide), Lower Rupununi R., 1908 (*K.S. Wise*), (BMNH).

as *Simulium (Trichodagmia) pintoi* Andretta & Andretta, **syn. n.**

Brazil: 1♀ PARATYPE (reared, thorax pinned remainder on slide, No.999), 1♂ PARATYPE (head & thorax pinned, abdomen and hind leg on slide, No.1020), 2 pupal exuviae PARATYPES (♂ on slide, No.1014 & ♀ on slide, No.987), **São Paulo State**, Piracicaba, 28.vii.1944 (*V. Andretta & Andretta Jr.*), (BMNH).

PINNED

Brazil: 18 man-biting ♀♀, **Roraima State**, mission post, R. Auaris, 7.vii.1976, 29.iii.–1.iv.1977, B.M.1979–580 (*R.R. Pinger*) & 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, Surucucucus, Dalem, 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 5♂ (reared), R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 9♀♀ (reared), 11♂♂ (reared), mission, R. Mucajaí, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 1♂ (reared), Catrimani mission, 9.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), Catrimani mission, R. Catrimani, 13.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♂♂ (reared), R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 2♂♂ (reared), Vila Pereira, R. Surumu, 25.xi.1980 (*A.J. Shelley*), (BMNH); 1♂ (reared), near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley*), (BMNH); 6 man-biting♀♀, **Amazonas State**, mission post, R. Toototobi, 24.x.1976, 26.ii.1976, 19.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀, mission post, R. Toototobi, 63°39'W, 1°47'N, 12.xii.1976, B.M.1979–580, 12.xii.1976 (*R.R. Pinger*), (BMNH); 3♀♀ (reared), **Amapá State**, above Maripa Falls, R. Oyapock, 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 21 man-biting ♀♀, 3♀♀ (reared), 1♂ (reared), **Pará State**, R. Iriri, 52°53'W, 3°50'S, vii.1984 (*T. Harvey*), (BMNH); 40 man-biting ♀♀, Altamira, 51°45'W, 3°33'S, vii.1984, (*T. Harvey*), (BMNH); 35 man-biting ♀♀, Uruá, R. Tapajós, 4°33'S, 56°19'W, 29.viii.1979, B.M.1979–580 (*L.A. Lacey*), (BMNH); 4 man-biting♀♀, 2♀♀ (reared, but no exuviae), 3♂♂ (reared but no exuviae), Amazonia Nacional Park, Uruá, R. Tapajós, 1.ix.1978, B.M.1979–580 (*L.A. Lacey*), (BMNH); 4 man-biting ♀♀, R. Anapu, 8.iv.1976, B.M.1979–580 (*W. Arouck*), (BMNH).

Guyana:1♀, R. Tumong, Orinduik, 2.xii.1970 (*J.B. Davies*), (BMNH).

Surinam: 2 man-biting ♀♀, Kabalebo River, Km 113, camp, 21.ix.1980 (16–17 hr) (*K.E. Neering*), (BMNH);3 man-biting ♀♀, Poeketi, Tapanahony River, 4°08'N 54°38'W, 19.i.1979 (18 hr) (*J.E. Hudson*), (BMNH); 1 man-biting ♀, Drierabberje, Tapanahony River, 9.v.1980 (17 hrs) (*H.J. Emanuels*), (BMNH); 2 man-biting ♀♀, Aseli Kamp, Lawa River, 24.v.1979 (*J.E. Hudson*), (BMNH); 1 man-biting ♀, Gran Santi, Lawa River, 15.xi.1979 (17 hrs) (*J.E. Hudson*), (BMNH); 2 man-biting ♀♀, Saje, Tapanahony River, 17.i.1979 (18 hrs) (*J.E. Hudson*), (BMNH); 1 man-bitng ♀, Apoma Tapoe, Marowijne, 19.xi.1979 (*J.E. Hudson*), (BMNH); 2 man-biting ♀♀, Kwamala Samoetoe, Sipaliwini River, 2°21'N, 56°47'W, 15.ii.1979 (18–19 hrs) (*J.E. Hudson*), (BMNH).

SLIDE MOUNTED

Brazil: 5 man-biting ♀♀, **Roraima State**, mission post, R. Auaris, 29.iii–4.iv.1977 (*R.R. Pinger*), (BMNH, IOC); 4♀♀ (reared), 1♂ (reared), Mucajaí mission post, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH, IOC); 3♀♀ (reared), 2♂♂ (reared), 5 larvae, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 2♂♂ (reared), Catrimani mission, R. Catrimani, 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4 man-biting ♀♀, **Amazonas State**, mission post, R. Tootototobi, 26.ii.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH, IOC); 2 man-biting ♀♀, R. Tootototobi, 1.xii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (dissected from pupa), **Amapá State**, R. Oyapock, Maripa Falls (above), 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 1 man-biting ♀, R. Limão, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH); 16 man-biting ♀♀, 1♂ (reared), **Pará State**, near Altamira, Laranjal, R. Iriri, Indian camp by riverside, 52°53'W 3°50'S, 1.iii.1984, vii.1984 (*T. Harvey*), (BMNH); 1 man-biting ♀, Km 360, Transamazonica road, (Maraba-Altamira), near R. Anapu, 8.iv.1976, B.M.1979–580, (*W. Arouk*), (BMNH); 2 man-biting ♀♀, Uruá, R. Tapajós, 56°19'W 4°33'S, 29.viii.1979, 1.ix.1978, B.M.1979–580 (*L.A. Lacey*), (BMNH).

Guyana: 6 man-biting ♀♀, Orinduik, R. Tumong, 2.xii.1970 (*J.B. Davies*), (BMNH).

Surinam: 1 man-biting ♀, Apoma Tapoe, Marowijne river, 19.xi.1979 (*J.E. Hudson*), (BMNH).

Venezuela: 1 man-biting ♀♀, **Amazonas State**, Coyoweteri, R. Orinoquito, 24 & 25.vii.1986 (*M.G. Basáñez*), (BMNH); 1 man-biting ♀, 1♀ (mass reared), **Bolivar State**, Via Caicara, Salto Chaviripa, 26.x.1986 (*V. Park et al.*), (BMNH).

SPIRIT MATERIAL

Brazil: numerous man-biting ♀♀, **Roraima State**, mission post, R. Auaris, 29.iii.–4.iv.1977 (*R.R. Pinger*) & 8.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 4♀♀ (reared), 13♂♂ (reared), 8 pupae, R. Mucajaí, mission post, 5.i.1977, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 pupa, several larvae, Mucajaí, 5.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀ (reared), 5♂♂ (reared), numerous pupae, numerous larva, R. Mucajaí, 200m below Igarapé Coroconaí, 21.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀ (mass reared), numerous pupae, 33 larvae, Mucajaí, Igarapé downriver from Coroconaí, 6.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 2♀♀ (reared), 5♂♂ (reared), 17 pupae, 3 pupal exuviae, several larva, northern perimeter road, Catrimani mission, R. Catrimani, 9.i.1977, B.M.1979–580 (*A.J. Shelley*) & 12.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*) & 9.i.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1 pupal exuviae, near Normandia, Fazenda Guanabara, R. Maú, 2.xii.1980 (*A.J. Shelley*), (BMNH); 2♂♂ (reared), Cachoeira Bem Querer, R. Branco, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 pupal exuviae, Cachoeira Bem Querer, near Caracaraí, R. Branco, 16.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 2♂♂ (reared), 2 pupae, 7 larvae, R. Uraricoera, 20.i.1979, B.M.1979–580 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 9♂♂ (reared), numerous pupae, Vila Pereira, R. Surumu, 25.xi.1980 (*A.J. Shelley*), (BMNH); 1♀, Serra dos Surucucus, FUNAI Post, 6.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 2 man-biting ♀♀, Surucucus, Igarapé in front of FUNAI , 9.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀, 10km north of junction of Boa Vista-Sta. Elena-Surumu road, waterfall, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1 pupa, 3 larvae, 14km from junction Vila Peraira road, Boa Vista to Sta. Elena road, rapids on R. Surumu, 11.viii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♀, **Amazonas State**, R. Tootototobi, 1.xii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♂ (reared), few pupae, several larvae, **Amapá State**, above Maripa Falls, R. Oyapock, 21.v.1992 (*C. Lowry & A.P.A. Luna Dias*), (BMNH); 15 man-biting ♀♀, R. Limão, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH); numerous man-biting ♀♀, **Pará State**, near Altamira, Laranjal, R. Iriri, 52°53'W 3°50'S, 1.iii.1984, vi.1984 (*T. Harvey*), (BMNH); few man-biting ♀♀, R. Xinga, near Altamira, 100km south southwest of Pirauhaguara, 52°34'W 4°8'S, 7.ii.1984 (*T. Harvey*), (BMNH); 1 man-biting ♀, near Itaituba, R. Uruá, 12.x.1977, B.M.1979–580 (*B. Ratcliffe*), (BMNH); several man-biting ♀♀, Km 360 Transamazonica road, (Maraba-Altamira), near R. Anapu, 8.iv.1976, B.M.1979–580 (*W. Arouck*), (BMNH); 5♀♀, Amazonia National Park, 1.ix.1978, B.M.1979–580 (*L.A. Lacey*), (BMNH); 1 man-biting ♀, **Mato Grosso State**, R. Aripuanã, Dardenelos Falls, 5.x.1977 (*D. Charlwood*), (BMNH); 2 pupae, 2 pupal exuviae, 8 larvae, **Goias State**, Brasilia-Campos Belos road, Km 299 from junction with Brasilia-Formosa highway, stream, 22.iv.1976, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀ (reared), 4♂♂ (reared), 3 pupae, 2 pupal exuviae, on road from Minaçu to Palmeiropolis, Fazenda do Fortuna do Isaac, R. Cana Brava, 1km below bridge, 14.x.1991 (*A.J. Shelley*), (BMNH); 1♂ (reared), 3 pupa, on road from Minaçu to Palmeiropolis, Fazenda Sto. Antonio, R. Mucambão, 14.x.1991 (*A.J. Shelley*), (BMNH); 5 pupae, 2 pupal exuviae, 2 larvae, near Minaçu, 4km below hydroelectric works of Serra da Mesa, R. Tocantins, 11.x.1991 (*A.J. Shelley*), (BMNH); 13♀♀, **Rio de Janeiro State**, Fregesia, road from Araticum, 9.v.1978, B.M.1979–580 (*M. Aragão & A.P.A. Luna Dias*), (BMNH).

Guyana: several man-biting ♀♀, Orinduik, R. Tumong, 2.xii.1970 (*J.B. Davies*), (BMNH).

Venezuela: 3 man-biting ♀♀, **Amazonas State**, Coyoweteri, R. Orinoquito, 24 & 25.vii.1986 (*M.G. Basáñez*), (BMNH); 2 man-biting ♀, 2♀♀ (mass reared), 2♂♂ (mass reared), **Bolivar State**, Via Caicara, Salto Chaviripa, 26.x.1986 (*V. Park et al.*), (BMNH).

Simulium (Trichodagmia) perplexum Shelley, Maia-Herzog, Luna Dias & Couch

TYPE MATERIAL

Guyana: 1♀ HOLOTYPE, 16♀♀ (13 pinned, 1 with abdomen, wing & fore leg on slide, 1 with head, wing & abdomen on slide; 3 on slide), 14♂♂ (11 pinned, 1 with abdomen on slide; 3 on slide), 1 pharate ♂ pupa (on slide) & 2 pupal exuviae (on slide) PARATYPES, Kaieteur Falls, 1, 4 & 9.ix.1937 (*O.W. Richards & J. Smart*), (BMNH); 1♀ PARATYPE, Amatuk

Falls, Potaro river, 31.viii.1937 (*O.W. Richards & J. Smart*), (BMNH); 3♀♀ PARATYPES, Warratuk Falls, Potaro river, 31.viii.1937 (*O.W. Richards & J. Smart*), (BMNH).

SLIDE MATERIAL

Guyana: 1♀ (head missing), Kaieteur Falls, 6.ix.1937 (*O.W. Richards & J. Smart*), (BMNH).

Simulium (Simulium) goeldii Cerqueira & Nunes de Mello

PINNED

Brazil: 3♀♀ (reared), 2♂♂ (reared), **Roraima State**, near Boa Vista, Igarapé Sta. Cecilia, 21.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2 man-biting ♀♀, 7km N.W. Boa Vista, R. Cauamé, 4.iv.1976 (*R. Pinger & E. Vieira*), (BMNH); 2♀♀ (reared), 1♂ (reared), 6km N.W. Boa Vista, Igarapé do Carana, 4.iv.1976 (*R. Pinger & E. Vieira*) & 16.viii.1977, B.M.1979–580 (*A.J. Shelley*), (BMNH); 1♀, S.W. Boa Vista, Km 8, BR 174, Igarapé Aizinho, 7.iv.1976 (*R. Pinger & E. Vieira*), (BMNH); 21♀♀ (19 reared), 5♂♂ (reared), Serra dos Surucucus, Igarapé do Posto FUNAI, 5.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH, IOC).

SLIDE MATERIAL

Brazil: 1♀ (reared), 2♂♂ (reared), 1 pupal exuviae , 5 larvae, **Roraima State**, Surucucus, Igarapé in front of FUNAI, 9.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH, IOC); 1 pupal abdomen, road to Embrapa, near R. Cauamé, Igarapé do Carrapato, 10.vii.1984, (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH).

SPIRIT MATERIAL

Brazil: 2♀♀ (reared), 1♂ (reared), 2 pupae, 1 exuviae, 1 larva, **Roraima State**, near Boa Vista, Igarapé Sta. Cecilia, 21 & 22–25.xi.1980 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 3♀♀ (reared), 3♂♂ (reared), 2 pupa, 1 exuviae, Serra dos Surucucus, Igarapé do Posto FUNAI, 5.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 6♀♀ (reared), 6♂♂ (5 reared), few pupae & exuviae, several larvae, Surucucus, Igarapé in front of FUNAI, 9 & 11.xii.1986 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 6♀♀ (reared; 2 without associated pupal exuviae), 6♂♂ (4 reared), 1 pupa, Surucucus, near FUNAI post, v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♀ (reared), 1♂ (reared), Surucucus, Cachoeira by FUNAI post, 6.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♀ (reared), Surucucus, American mission, 12.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 1♂ (reared), Surucucus, Igarapé 2km from mission at FUNAI post, 12.v.1982 (*A.P.A. Luna Dias & R. Malaguti*), (BMNH); 9 pupae (1 abdomen on slide), 1 pupal exuviae, 3 larvae, road to Embrapa, near R. Cauamé, Igarapé do Carrapato, 10.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 2♀♀ (reared), 2 pupae, near Boa Vista, Igarapé Caraná, 9.v.1978, B.M.1979–580 (*A.J. Shelley*), (BMNH); 3♀♀ (reared; 1 without associated pupal exuviae), 1♂ (without pupal exuviae), Cantar-Boa Vista road, un-named stream, 28.vii.1984 (*A.J. Shelley & A.P.A. Luna Dias*), (BMNH); 1♂ (reared), 1 pupa (with ♀ emerging), **Amapá State**, R. Limão Branco, 22.v.1982 (*A.P.A. Luna Dias*), (BMNH).

APPENDIX 2

Data on biting catches and parous rates

Toototobi December 1975, *S. oyapockense / S. roraimense*

Hours	Biting catches			Mw	%Mw
6–7	7	0	2	1.88	0.22
7–8	22	5	11	10.83	1.25
8–9	42	9	22	20.47	2.36
9–10	60	24	26	33.53	3.87
10–11	65	44	46	50.87	5.87
11–12	42	22	85	42.98	4.96
12–13	70	25	40	41.30	4.77
13–14	94	53	118	83.83	9.68
14–15	234	148	121	161.26	18.61
15–16	388	171	115	196.99	22.74
16–17	262	197	87	165.10	19.06
17–18	85	71	25	53.40	6.16
18–19	9	3	2	3.93	0.45
19–20	–	–	–	–	–
Totals	1380	772	700	866.37	100.00

Toototobi August 1976, *S. oyapockense / S. roraimense*

Hours	Biting catches			Mw	%Mw
6–7	0	1	0	0.26	0.90
7–8	0	2	1	0.82	2.82
8–9	3	1	3	2.17	7.51
9–10	6	1	2	2.48	8.55
10–11	4	7	3	4.43	15.29
11–12	2	7	3	3.58	12.36
12–13	3	4	5	3.93	13.58
13–14	2	2	1	1.62	5.60
14–15	3	3	2	2.63	9.10
15–16	1	0	1	0.59	2.03
16–17	2	1	16	3.67	12.68
17–18	5	0	8	2.78	9.60
18–19	0	0	0	0.00	0.00
19–20	–	–	–	–	–
Totals	31	29	45	28.96	100.02

Toototobi February 1976, *S. oyapockense / S. roraimense*

Hours	Biting catches				Mw	%Mw	°C	RH	Nulliparous	Parous	% Parous (/hr)
6–7	0	0	0	0	0.00	0.00	–	–	–	–	–
7–8	4	20	35	5	11.27	4.39	23	90	1	10	90.9
8–9	17	30	28	16	21.90	8.53	25	90	6	19	76.0
9–10	25	50	75	19	36.68	14.29	26	90	4	11	73.3
10–11	17	42	92	4	23.49	9.15	28	85	6	29	82.9
11–12	33	67	113	9	39.29	15.31	30	75	8	31	79.5
12–13	6	25	48	4	13.53	5.27	30	73	2	15	88.2
13–14	22	38	38	1	15.26	5.95	30	71	2	22	91.7
14–15	8	33	122	10	24.37	9.49	30	72	15	51	77.3
15–16	14	36	50	8	21.47	8.36	30	72	7	22	75.9
16–17	11	26	72	12	22.55	8.78	30	72	10	30	75.0
17–18	9	25	46	11	18.57	7.23	28	75	5	8	61.5
18–19	5	9	17	6	8.32	3.24	26	82	0	5	100.00
19–20	–	–	–	–	–	–	26	84	–	–	–
Totals	171	401	736	105	256.70	99.99	/	/	66	253	/

Toototobi October 1976, *S. oyapockense / S. roraimense*

Hours	Biting catches			Mw	%Mw	°C	RH	Nulliparous	Parous	% Parous (/hr)
6–7	18	5	13	10.69	2.07	–	–	–	–	–
7–8	22	4	51	17.15	3.33	23	90	–	–	–
8–9	18	37	75	37.00	7.18	25	88	5	0	0
9–10	12	48	140	43.78	8.50	27	79	9	0	0
10–11	33	49	110	56.36	10.94	30	75	1	0	0
11–12	36	39	90	50.26	9.76	31	72	2	0	0
12–13	52	20	40	34.73	6.74	31	66	9	0	0
13–14	31	28	19	25.48	4.95	30	69	9	1	10
14–15	27	50	56	42.34	8.22	29	71	9	0	0
15–16	36	52	139	63.99	12.42	30	76	4	0	0
16–17	85	24	104	59.89	11.63	30	75	1	0	0
17–18	84	60	66	69.30	13.45	28	79	1	0	0
18–19	2	22	1	4.17	0.81	27	83	–	–	–
19–20	–	–	–	–	–	–	–	–	–	–
Totals	456	438	904	515.14	100.00	/	/	50	1	/

Toototobi August 1977, *S. oyapockense / S. roraimense*

Hours	Biting catches			Mw	%Mw	°C	RH
6–7	0	0	0	0.00	0.00	–	–
7–8	3	2	6	3.38	2.71	22	90+
8–9	15	6	6	8.22	6.60	23	82
9–10	3	7	15	7.00	5.62	27	81
10–11	27	20	4	13.32	10.70	29	72
11–12	24	28	2	11.96	9.60	29	78
12–13	20	21	11	16.70	13.41	28	77
13–14	13	17	9	12.61	10.13	29	72
14–15	45	21	8	19.88	15.97	30	69
15–16	16	26	5	13.02	10.45	30	71
16–17	19	21	8	14.82	11.90	31	67
17–18	1	6	6	3.61	2.90	27	90+
18–19	0	0	0	0.00	0.00	27	90+
19–20	–	–	–	–	–	22	90+
Totals	186	175	80	124.52	99.99	/	/

Toototobi December 1977, *S. oyapockense / S. roraimense*

Hours	Biting catches			Mw	%Mw	°C	RH
6–7	0	0	0	0.00	0.00	–	–
7–8	2	0	2	1.08	2.80	23	90+
8–9	3	4	2	2.92	7.57	24	87
9–10	8	2	0	2.00	5.19	26	79
10–11	8	9	7	7.96	20.67	28	69
11–12	2	2	1	1.62	4.21	29	64
12–13	6	4	2	3.72	9.65	30	62
13–14	0	3	2	1.29	3.35	29	61
14–15	5	5	3	4.24	11.01	31	60
15–16	4	11	5	6.11	15.87	31	60
16–17	9	4	3	4.85	12.58	31	61
17–18	5	6	0	2.48	6.43	29	64
18–19	0	1	0	0.26	0.68	27	72
19–20	–	–	–	–	–	27	83
Totals	52	51	27	38.53	100.01	/	/

Toototobi August 1976, *S. exiguum*

Hours	Biting catches			Mw	%Mw
6–7	0	0	0	0.00	0.00
7–8	0	0	0	0.00	0.00
8–9	0	0	1	0.26	0.64
9–10	1	1	0	0.59	1.45
10–11	2	3	0	1.29	3.19
11–12	9	17	5	9.26	22.89
12–13	16	16	12	14.55	35.95
13–14	1	16	9	5.98	14.78
14–15	0	6	0	0.91	2.26
15–16	2	5	0	1.62	4.01
16–17	0	25	3	3.70	9.15
17–18	2	1	5	2.30	5.69
18–19	–	–	–	–	–
19–20	–	–	–	–	–
Totals	33	90	35	40.46	100.01

Auaris July 1976, *S. incrustatum*

Hours	Biting catches				Mw	%Mw	°C	RH
6–7	0	0	0	0	–	–	19.5	–
7–8	2	4	9	2	3.6	2.6	20.0	90.0
8–9	6	14	14	12	11.0	7.9	22.2	87.5
9–10	16	5	11	18	11.3	8.2	24.3	85.5
10–11	20	5	21	23	15.1	10.9	25.9	85.0
11–12	23	11	26	35	22.0	15.9	26.8	72.0
12–13	18	12	11	35	17.1	12.4	26.8	79.0
13–14	18	8	5	26	12.0	9.4	26.3	71.0
14–15	18	12	15	60	21.2	15.3	26.1	66.5
15–16	2	6	10	19	7.2	5.2	24.6	80.0
16–17	24	4	3	26	9.8	7.1	24.0	83.0
17–18	27	2	2	7	5.7	4.1	23.6	83.0
18–19	1	1	6	3	2.2	1.6	22.2	90.0
19–20	–	–	–	–	–	–	22.0	90.0
Totals	175	84	133	266	138.2	100.6	/	/

Auaris March 1977, *S. guianense*

Hours	Biting catches				Mw	%Mw
6–7	0	0	0	0	–	–
7–8	4	4	1	0	1.7	1.5
8–9	0	4	2	0	1.0	0.9
9–10	3	23	5	0	3.9	3.3
10–11	1	8	9	0	2.7	2.3
11–12	1	10	14	0	3.3	2.8
12–13	12	7	19	1	7.0	6.0
13–14	23	39	1	4	8.9	7.6
14–15	19	27	47	25	27.9	23.9
15–16	31	30	28	13	24.2	20.7
16–17	26	27	16	11	18.8	16.1
17–18	15	21	22	8	15.4	13.2
18–19	2	4	1	1	1.8	1.5
19–20	–	–	–	–	–	–
Totals	137	204	165	63	116.6	99.8

Catrimani January 1977, *S. oyapockense/S. roraimense*

Hours	%Mw	°C	RH
6–7	0.00	–	–
7–8	0.50	24.2	86.0
8–9	9.50	26.8	79.0
9–10	14.00	28.0	74.3
10–11	7.25	30.3	67.0
11–12	3.25	31.3	62.3
12–13	2.25	32.0	58.3
13–14	3.00	33.3	55.3
14–15	7.50	33.5	54.3
15–16	9.25	33.3	54.3
16–17	13.75	33.0	54.0
17–18	12.00	31.3	58.7
18–19	16.00	28.3	64.0
19–20	1.75	26.3	75.7
Totals	100.00	/	/

Catrimani January 1979, *S. oyapockense/S. roraimense*

Hours	Biting catches			Mw	%Mw	°C	Nulliparous	Parous	% Parous (/hr)
6–7	0	0	0	–	–	–	–	–	–
7–8	24	40	25	28.9	4.1	22.70	31	11	26.2
8–9	45	47	67	52.1	7.5	23.30	48	21	30.4
9–10	32	19	27	25.4	3.6	25.80	29	13	31.0
10–11	48	32	33	37.0	5.3	27.70	19	8	29.6
11–12	63	86	20	47.9	6.9	29.70	42	21	33.3
12–13	32	65	25	37.4	5.4	30.50	62	1	1.6
13–14	41	131	63	69.8	10.0	32.00	31	2	3.1
14–15	128	113	72	100.6	14.4	32.30	46	3	6.1
15–16	68	60	82	69.4	10.0	31.00	43	2	4.4
16–17	105	86	98	96.0	13.8	32.00	46	4	8.0
17–18	114	99	109	107.1	15.4	31.00	49	1	2.0
18–19	22	30	23	24.8	3.6	29.75	24	1	4.0
19–20	–	–	–	–	–	–	–	–	–
Totals	722	808	644	696.4	100.00	/	470	88	/

Catrimani July 1984, *S. oyapockense/S. roraimense*

Hours	Biting catch	%
6–7	203	2.99
7–8	407	6.00
8–9	929	13.70
9–10	590	8.70
10–11	476	7.02
11–12	653	9.63
12–13	581	8.57
13–14	156	2.30
14–15	812	11.98
15–16	618	9.12
16–17	717	10.58
17–18	473	6.98
18–19	165	2.43
19–20	–	–
Totals	6780	100.00

Catrimani July 1984, *S. exiguum*

Hours	Biting catch	%
6–7	2	0.73
7–8	2	0.73
8–9	5	1.83
9–10	0	0.00
10–11	1	0.37
11–12	6	2.20
12–13	10	3.66
13–14	2	0.73
14–15	80	29.30
15–16	7	2.56
16–17	27	9.89
17–18	50	18.32
18–19	81	29.67
19–20	–	–
Totals	273	99.99

Seasonal Fluctuations in Populations of Simuliids at Tootobi

Date	River Depth (m)	*S. oyapockense/S. roraimense* Biting rates (Mw/man/day)	*S. guianense* Biting rates (Mw/man/day)	*S. exiguum* Biting rates (Mw/man/day)
Dec. 75	4.0	866.37	< 1.00	<1.00
Feb. 76	1.7	256.70	< 1.00	0.00
Aug. 76	0.5	28.96	< 1.00	40.46
Oct. 76	2.2	515.14	< 1.00	14.00
Aug. 77	1.1	124.52	1.30	< 1.00
Dec. 77	0.2	38.53	< 1.00	0.00

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Synonyms and misidentifications are in italics; main citations in **bold**